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CALABASAS, CALIFORNIA 91302

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Rantec Doc. No. ET-300-TM 1 February 1972

TECHNICAL MANUAL

for

TIME DELAY INDICATOR INSTRUMENTS
(RANTEC MODEL ET-300)

Revision B

RANTEC DIVISION
EMERSON ELECTRIC CO.
CALABASAS, CALIFORNIA

CHANGE RECORD

PAGE	REF PARA	CHANGE	DATE	APPROVAL
Title	---	Original Issue 109 Pages	2/1/72	
Title	---	Revision A 110 Pages 1 page ADDENDUM (pertaining to Section 7, pages 7-5 and 7-9)	10/19/73	
Title	---	Revision B 114 Pages ADDENDUM (pertaining to Section 4, pages 4-1 through 4-14 - also incorporating ADDENDUM of 10/19/73)	2/23/83	

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ADDENDUM

(Including 19 October 1973 Addendum)

Section 4 Page 4-1 Para. 4-1

is: Extender Card Rantec 05060047-1

was: Extender Card Rantec 66369699

Page 4-2 Figure 4-1 Top View

is: +15VDC ADJ (thru rear panel)

was: -15VDC ADJ

is: -15VDC ADJ (inside)

was: +15VDC ADJ

To Meter

is: Sensitivity R817

was: Sensitivity R811

is: 1MHz ZCD zero R237

was: ZCD zero R237

Add between balance modulator and rear panel a position for "200 KHz ZCD zero R257"

Page 4-4 Para. 4-2.f

Correct the Para. to read as follows:

f. Place power switch in OFF position and replace the frequency generator card removed in step a in card connector 2. Switch power switch to ON and recheck +4V power supply.

Page 4-5

Add: Para b. Turn modulation frequency switch to 200KHz position.

Change: Para. "b" to read Para. "c".

Change: Para. "c" to read Para. "d".

Add: Para. "e" Turn modulation frequency switch to 1MHz position.

Change: Para. "d" to read Para. "f".

Page 4-5 (Cont'd)

Change: Para. "e" to read Para. "g".
Change: Para. "f" to read Para. "h";
Change: Para. "h" to read:
Observe 2 KHz wave form at resistor R738 on filter card.
Change: Para. "g" to read Para. "i".
Change: Para. "h" to read Para. "j".
Add: Para. 4-4.d.: (Select R202 for range).
Add: Para. 4.4.f.: (Select R710 for range).

Page 4-6 Para. 4-5

General: 1. From here on any reference to maximum permitted input signal shall be 0.7 VPP and not 1.0 VPP.
2. Signal level at TP1301 shall be 3.6 VPP and not 6 VPP. The 0.7 VPP is measured accross the "flats" (1M or 200 KHz modulation).

Page 4-6 Para. 4-5.c

Add: "... observed, adjust GAIN control, R222, to obtain..."

Page 4-8 Para. 4-5.h

Correct: "If a..adjust PHASE control R213...
was: AMPL BAL; R212
... adjust AMPL BAL control R212 to obtain..."
was: Phase; R213

Page 4-7 Figure 4-5

Photo upper left: is: Adjust PHASE R213
was: Adjust AMPL BAL R212

upper and lower right,
is: Adjust AMPL BAL R212
was: Adjust PHASE R213

Page 4-6 Para. 4-5c.

Add: "Note;:measured wavefore at the junction of C225 and R236, shall be no more than 6 VPP to coincide with 3.6 VPP at T01301 and 0.7 VPP input."

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Page 4-8 Para. 4-5i

Add: "A 1 cm variation is permitted."

Page 4-8 Para. 4-6

Add: "Note: Readjust level when switching to 200 KHz."

Para. 4-6a

is: 0.7 VPP

was: 1 VPP

Para. 4-6b

is: 3.6 VPP

was: 6 VPP

Para. 4-6c

Add: "Zero T.D. Meter"

Para 4-6d

is: "Increase 5 dB...

was: "Introduce 5 dB...

Page 4-9 Para. 4-6j

Correct: "with 20 dB attenuation..."

was: 10dB

Add: "Return to orginal attenuator dB setting."

Page 4-10 Para. 4-8k

Add: "Check plus side of meter for 400 usec."

Para. 4-8p

Add: "Check ranges 50/150 for full scale. Check voltages at TD out at full scale voltage; shall not vary more than 1% for 5,15,50,150.

Para. 4-9a

Correct to read:

... Cable B,... to Cable A input connector __ with Cable B input shorted."

Para. 4-9a NOTE:

Add: "If level meter moves wrong way add inductance. During adjustments maintain level meter in upper 2/3 green by varying external attenuators. Turn off time meter before connecting/disconnecting BNC's."

Page 4-11 Para. 4-9b

Correct to Read: "Connect cable B to resolver Cable A input and adjust... scale.

Para. 4-9e.

Correct to Read: "Disconnect cable B and connect Cable A.

Figure 4-7

is: PHASE ADJ R319

was: 2 KHz PHASE ADJ R319

Page 4-13 Para. 4-10B

is: 0.7 VPP

was: 1.0 VPP

Figure 4-8

is: PHASE ADJ R419

was: 2 KHz PHASE ADJ R419

Page 4-14 Para 4-10c

is: 0.7 VPP

was: 1.0 VPP

Para. 4-10d

is: 3.6 VPP

was: 6 VPP

Para. 4-10e

is: 3.6 VPP

was: 6 VPP

Page 4-1 SECTION IV ALIGNMENT PROCEDURES

Add: The alignment procedure set forth is typical for new production units, followed by MTP110, Manufacturing Test Procedure for ET-300 Time Delay System. For units in the field, some paragraphs should be performed under RF editions i.e. Para 4.6 Zero Crossing detector threshold adjustments. Whenever possible perform alignment under as used conditions; a ET-300 with normal modulator and detector used with it and necessary RF power.

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Doc. No. ET-300-TM

23 February 1983

ADDENDUM

Section 7, Page 7-5, Item 17

is MS-22
should be MSS-22

Section 7, Page 7-5, Item 37

is MTA100E1S
should be MTA1100F35

Section 7, Page 7-9, Item 4

80 MFD, 30 WVDC Capacitor, Mallory part number 20-46148, is used in older ET-300 units. This part is no longer available from Mallory and has been replaced with a 90 MFD, 35 WVDC capacitor, Mallory part number MTV90CK35.

RANTEC DIVISION
EMERSON ELECTRIC CO.
CALABASAS, CALIFORNIA

FOREWORD

This manual describes the Rantec ET-300 Series of Time Delay Measurement Instruments presently being manufactured. Included is a number of design improvements over earlier models. The current Electronic Units will function with all previously delivered Modulator and Detector Units. Care must be taken to place the bias switch on the rear of the Electronic Unit to the "A" position when using these older modulators; they are not marked as to required bias. The new ET-300M-B (0.5 to 8 GHz) Modulator will not function with the older ET-300E Electronic Units. A modification kit is available for these older Electronic Units, or they may be returned for modification.

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SECTION I
INTRODUCTION

1-1. SYSTEM DESCRIPTION.

The Rantec ET-300 series of Time Delay Indicator Instruments measure the group delay as an RF signal (amplitude modulated at a 1-MHz or 200-kHz rate) is passed through a device under test. The series consists of a single Electronic Unit and a series of RF Modulator Units and RF Detector Units associated with particular RF bands (see Figure 1-1). The complete series provide the measurement capability over the band from 20 MHz to 18 GHz. The four modulator units and three detector units listed below are used to cover this range. Modulator and detector interchangeability permits testing of frequency translation devices.

RF Modulator Units	RF Detector Units
ET-300M-A	ET-300D-AB
ET-300M-B	ET-300D-X
ET-300M-X	ET-300D-Ku
ET-300M-Ku	

Figure 1-2 illustrates how the three elements of a Time Delay Indicator are connected to an external RF source and to the device to be tested. A typical coaxial system has been shown. The RF source provides a CW RF signal (in either a fixed frequency or a swept frequency mode). Within the Modulator Unit, this CW signal is amplitude modulated by the 1-MHz or 200-kHz signal supplied by the Electronic Unit. The modulated RF signal is passed through the device under test where it encounters a group delay. This delay appears as a phase shift in the envelope signal that is recovered in the Detector Unit. The recovered signal is processed in the Electronic Unit to obtain a direct-reading indication of delay on a front panel meter of the unit. A dc voltage proportional to the delay is available at an output connector for use in displaying delay on an oscilloscope or plotting delay on a recorder when operating in the swept frequency mode. A dc voltage, approximately proportional to the square of the signal voltage supplied to the Detector Unit, is available at a second jack for use in providing an amplitude response display or plot of the device under test.

A manually controlled phase shift resolver provides the means for offsetting any fixed value of delay. This is used to offset residual delay introduced by the Time Delay Indicator and the interconnecting cables of the measurement system. To accomplish this, the resolver is adjusted for zero time delay indication with the Modulator Unit output

Figure 1-1. ET-300 Time Delay Instruments

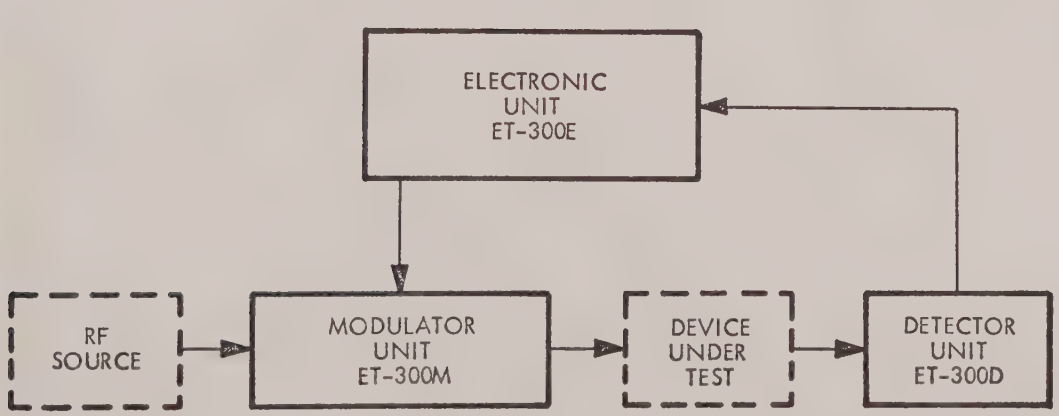


Figure 1-2. Time Delay Instruments, Simplified Block Diagram

connected directly to the Detector Unit input. When the device being tested is inserted into the test setup, only the time delay introduced by the device is displayed on the meter. The phase shift resolver is also used to offset large values of delay introduced by the device under test to allow operation on a more sensitive scale. In this case, the principal component of the time delay is indicated in terms of the change in the reading of a precision dial that is coupled to the resolver shaft, while the remaining component is indicated by the offset of the indication from the zero position on the expanded scale.

1-2. SYSTEM SPECIFICATIONS.

The specifications for the ET-300 series of Time Delay Indicator Instruments are as follows:

RF Power	10-mw CW into Modulator Unit provides full dynamic range. Modulated RF output ~0.1 mw (-10 dbm) max to detector or unit under test
Modulated Frequencies	1.0 MHz or 0.2 MHz
Delay Readout:	
Unambiguous range	
1.0 MHz	1000 nsec
0.2 MHz	5000 nsec
Linear scales on meter and displays	
1.0 MHz	±5, ±15; ±50, ±150; ±500 nsec
0.2 MHz	±25, ±75; ±25, ±750; ±2500 nsec
Amplitude Readout	Dc output for oscilloscope or recorder
	Square-law response
Video Bandwidths:	
Switch position 1	175 Hz nom
Switch position 2	90 Hz nom
Switch position 3	35 Hz nom

Delay Indication Variation (0-10 db of RF attenuation):	
1.0 MHz	±0.05 nsec/db max
0.2 MHz	±0.25 nsec/db max
Residual Variation vs Frequency (correctable by subtraction):	
Coaxial RF modules	±3 nsec/octave, ±1 nsec/10% band, typical (except for 12-nsec slope in 20-30 MHz band)
Waveguide RF modules	±2 nsec in full band, ±1 nsec/10% band, typical
Accuracy of Absolute and Relative Delay Measurements:	
1.0 MHz (fixed)	±0.1 nsec ± 2% (not exceeding ±5 nsec)
0.2 MHz (fixed)	±0.5 nsec ± 2% (not exceeding ±25 nsec)
1.0 MHz (swept)*	±0.3 nsec ± 2% (not exceeding ±6 nsec)
0.2 MHz (swept)*	±1 nsec ± 2% (not exceeding ±26 nsec)

NOTE

Accuracies apply to expanded delay scales used in conjunction with delay offset dial. On -500 to +500 and -2500 to +2500 nsec scales, an additional ±1% reading error is permitted.

RF Detector Units:	
ET-300D-AB (20 MHz - 8.0 GHz)	Test Terminal - Coaxial N Male**
ET-300D-X (8.0 - 12.4 GHz)	Test Terminal - Waveguide WR-90
ET-300D-Ku (12.4 - 18 GHz)	Test Terminal - Waveguide WR-62

* Includes correction for residual deviation (typical errors are given; affected by VSWR, bandwidth, complexity and round trip attenuation of unit under test)

**Other connectors (including GR-874, GR-900, and Amphenol APC-7) are optional on special order

RF Modulator Units:

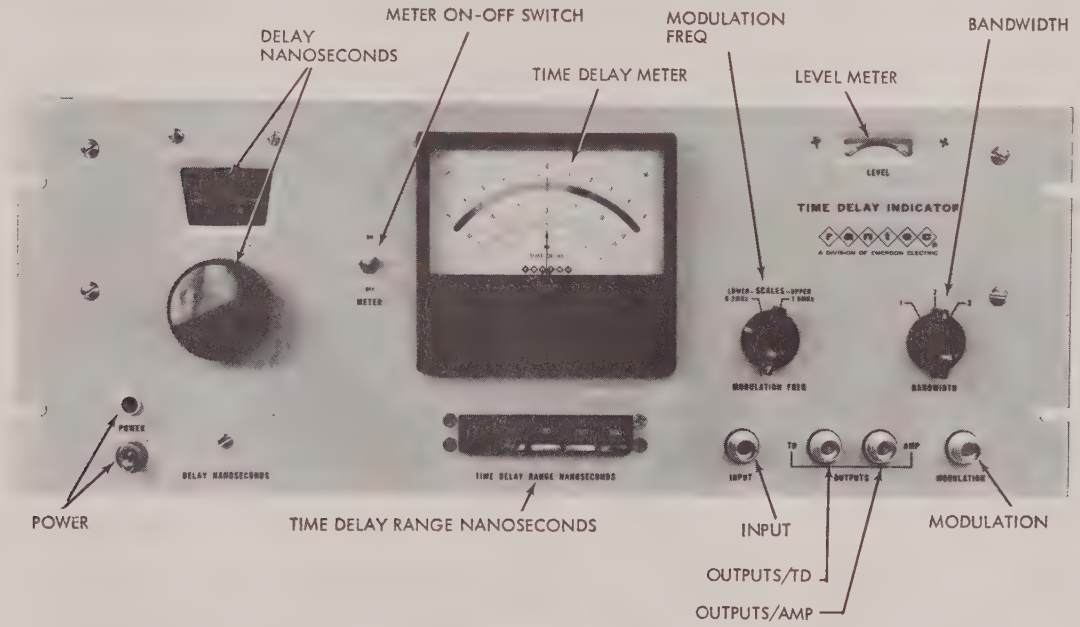
ET-300M-A (20 - 500 MHz)	Test Terminal - Coax N Female* Input Terminal - Coax N Female
ET-300M-B (0.5 - 8.0 GHz)	Test Terminal - Coax N Female* Input Terminal - Coax N Female
ET-300M-X (8.0 - 12.4 GHz)	Test Terminal - Waveguide WR-90 Input Terminal - Coax N Female
ET-300M-Ku (12.4 - 18 GHz)	Test Terminal - Waveguide WR-62 Input Terminal - Waveguide WR-62

*Other connectors (including GR-874, GR-900, and Amphenol APC-7) are optional on special order

SECTION II
OPERATION

2-1. OPERATING CONTROLS AND INDICATORS.

Operating controls, indicators, and input-output connectors for the ET-300 Time Delay Indicator Instruments are shown in Figure 2-1.



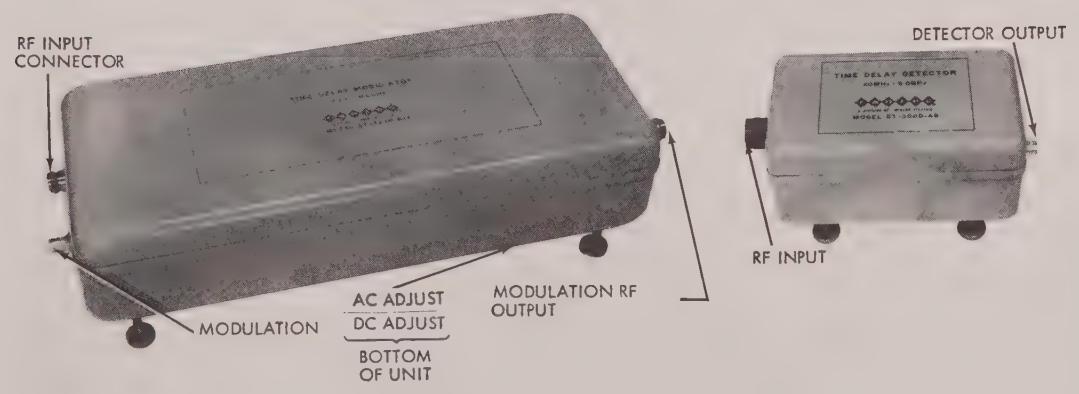


Figure 2-1. ET-300 Time Delay Indicator Instruments, Controls and Indicators

2-2. Electronic Unit.

POWER Switch and Indicator.

The POWER switch controls the application of primary power to the power supplies of the Electronic Unit. The POWER indicator lights when primary power is applied to the power supplies.

DELAY NANOSECONDS Control and Dial.

The DELAY NANOSECONDS control provides the means of offsetting any required value of time delay. This capability is used to offset residual delay introduced by the Time Delay Instrument and associated cables before the device to be tested is inserted in the test setup. It is also used to offset large values of delay introduced by the device under test to allow variations of delay with respect to this offset value to be measured on an expanded scale.

The DELAY NANOSECONDS dial has two scales to provide direct reading in nanoseconds for either of the two modulating frequencies. For the 1-MHz modulating frequency (white scale), 1000 nsec corresponds to a dial rotation of 360°; while for the 200-kHz modulating frequency (red scale), 5000 nsec corresponds to a dial rotation of 360°. The indexing of the DELAY NANOSECONDS dial is arbitrary. Thus, the value of time delay indicated by the dial reading under any particular test condition has meaning only with respect to the reading under some reference condition.

METER ON-OFF Switch.

This switch controls the application of the time delay signal to the TIME DELAY meter. The meter should be turned off to prevent damage under certain swept frequency measurements when using an oscilloscope or recorder to display time delay.

TIME DELAY Meter and TIME DELAY RANGE NANOSECONDS Pushbutton Switches.

The TIME DELAY meter indicates positive or negative time delay in nanoseconds on any of five scales. The scale to be used is selected by actuating one of the five pushbuttons in the interlocked TIME DELAY RANGE NANOSECONDS array. This selection also determines the scale of the time delay signal supplied to the TD connector for use in displaying or recording time delay. The significance of each scale selection depends upon the modulation frequency that is in use. The upper

(white) numbers on the pushbuttons indicate the scale selections for the 1-MHz modulating frequency, while the lower (red) numbers indicate the scale selections for the 200-kHz modulating frequency.

With no signal applied (no RF to modulator, modulator-detector open, etc.), the TIME DELAY meter indicates a full-scale negative delay.

To measure the absolute delay introduced by a device under test, the TIME DELAY meter is first zeroed using the DELAY NANOSECONDS control, with the RF Modulator Unit output connected directly to the Detector Unit input. The device to be tested is then inserted between the Modulator Unit and the Detector Unit. To obtain the greatest possible resolution in measurement of the delay, the DELAY NANOSECONDS control is then adjusted as required to obtain an on-scale reading on the TIME DELAY meter with the most sensitive scale selected. The total delay introduced by the device under test is then the change in the DELAY NANOSECONDS dial reading plus the TIME DELAY meter reading.

MODULATION FREQ Switch.

This switch selects either 1.0 MHz or 200 kHz as the modulation frequency. The notations UPPER and LOWER associated with the two switch positions indicate that, for the 1.0-MHz position, the upper scales on the TIME DELAY meter, DELAY NANOSECONDS dial, and TIME DELAY RANGE NANOSECONDS pushbutton switches should be used while for the 0.2-MHz position, the lower scales should be used.

LEVEL Meter.

The LEVEL meter is used to adjust the power level of the RF source so that the signal level supplied to the Electronic Unit is within the range where the specified accuracy of measurement can be achieved. The green band on the meter scale indicates the permissible power level range. An improved signal-to-noise ratio is obtained by operating at the high end of the permissible range. Operation at reduced accuracy and increasing noise is possible considerably below (up to 10-db RF) the bottom of the green band.

BANDWIDTH Switch.

This switch is used to restrict the bandwidth of the TD and AMP outputs from the Electronic Unit to obtain a smoother oscilloscope display or recorder record. The greatest bandwidth is provided in position 1.

Shunt capacitance is added in position 2, and additional shunt capacitance is added in position 3. The nominal response times are 2, 15, and 50 msec, respectively.

INPUT Connector.

This connector accepts the output signal from the RF Detector Unit. It also supplies ±15 volts (decoupled) to operate the preamplifier in the Detector Unit. The +15 volts is supplied via a 0.1-ampere fuse which protects the power supply if the center conductor is returned to ground through an impedance of less than 150 ohms. In practice, only the Detector Unit output should be connected to the INPUT connector.

TD and AMP OUTPUTS.

The signal appearing at the TD connector has a dc level that is proportional to the measured value of time delay. The scale of this signal is determined by the status of the TIME DELAY RANGE NANOSECONDS pushbutton array. Oscilloscope or recorder calibration on one range is monitored on all other ranges.

The signal appearing at the AMP connector has a dc level that is proportional to the square of the signal level received by the RF Detector Unit. The magnitude of this signal is independent of the status of the TIME DELAY RANGE NANOSECONDS pushbutton array. Since it is proportional to the RF generator power level as well as the attenuation characteristic of the device under test, leveling of the RF source is desirable for the test unit amplitude information.

MODULATION Connector.

The modulation signal selected by means of the MODULATION FREQ switch appears at this connector. The signal contains a dc component required by the modulator. This component is supplied from the +15 volt line via a 1000-ohm resistor. As a result of this arrangement, any additional loading placed in parallel with the impedance presented by the Modulator Unit can have an adverse effect on unit operation.

Modulator BIAS Switch.

The correct polarity of dc bias is selected by this switch as required by the various modulators that are used with the ET-300 Time Delay Indicator Instruments. The required bias is indicated on the modulator being used.

2-3 Modulator Unit.

AC Adjust

The ac adjustment provided on the bottom of the Modulator Unit is used to set the ac value on the Electronic Unit LEVEL meter. The ac signal level is adjusted for maximum indication on the meter.

DC Adjust

The dc adjustment provided on the bottom of the Modulator Unit is used to set the dc value on the Electronic Unit LEVEL meter. The DC level is adjusted for maximum indication on the meter.

MODULATION RF OUTPUT Connector

The MODULATION RF OUTPUT connector provides the RF signal which is passed through the device under test. As the signal is processed through the device under test it encounters a group delay.

RF INPUT Connector

The RF INPUT connector accepts an RF CW signal from the signal generator for amplitude modulation by the 1-MHz or 200 kHz signal as selected by the MODULATION FREQ switch on the Electronic Unit.

MODULATION Connector

The MODULATION input connector accepts 1-MHz or 200 kHz signal plus the dc voltage from the Electronic Unit for signal modulation.

2-4 Detector Unit.

RF INPUT Connector

The RF INPUT connector accepts the delayed RF output from the device under test. The signal is processed to detect envelope phase shift.

DETECTOR OUTPUT Connector

The DETECTOR OUTPUT connector provides the recovered envelope signal for processing by the Electronic Unit, which gives a direct reading indication of delay on the TIME DELAY meter.

2-5. OPERATING PROCEDURES.

CAUTION

Connect only the RF Detector Unit output to the INPUT connector of the Electronic Unit to avoid blowing the input current fuze.

Perform the procedures of paras. 2-6 through 2-9, in order, as applicable to the selected mode of operation.

2-6. Test Set-Up and Starting Procedure.

a. Connect RG-55/U or equivalent cable from MODULATOR connector on Electronic Unit to modulation input connector of Modulator Unit associated with RF band of interest.

b. Connect suitable RF source to RF input of Modulator Unit. A 10-milliwatt CW input into the Modulator Unit is required to provide full dynamic range of measurement. For swept frequency operation, the sweep rate should not exceed 30 Hz.

c. Connect RG-55/U or equivalent cable from INPUT connector on Electronic Unit to output connector of Detector Unit associated with RF band of interest.

d. For swept frequency mode operation, connect cable from OUTPUTS/TD connector to vertical input of oscilloscope or recorder. Connect sweep output of RF source to horizontal input.

e. To obtain amplitude response display or plot in swept frequency mode, connect cable from OUTPUTS/AMP connector to vertical input of oscilloscope or recorder. Connect sweep output of RF source to horizontal input.

f. Connect power cord of Electronic Unit to source of 115-volt, 60-Hz power.

g. Set POWER switch to ON position and observe that POWER light illuminates.

h. To obtain greatest accuracy, allow 15 minutes for equipment warm up.

2-7. Offsetting or Plotting Residual Delay of Measurement System.

NOTE

The procedures described in paras 2-7 through 2-9 require special precautions when the unit under test incorporates frequency translation and/or is active and has gain. For these cases, refer to application notes in the Appendix.

a. Connect Modulator Unit output to Detector Unit input.

b. Position MODULATION FREQ switch to select 1.0 MHz or 0.2 MHz as the modulation frequency. The 1.0-MHz modulation frequency provides the smallest time delay measurement resolution (±5 nsec full scale) and an unambiguous range of 1000 nsec. The 200-kHz modulation frequency provides an unambiguous range of 5000 nsec and provides greater accuracy in the case of devices whose bandwidth is so narrow that the measurement accuracy is affected by the 2 MHz separation of the upper and lower modulation sidebands that occurs when the 1.0-MHz frequency is used. Also the time delay resolution versus RF frequency (fine grain structure) is greater.

c. Adjust power output level of RF source for LEVEL meter indication within green tolerance band. It is advantageous to operate at the high end of the allowable band. However, for swept frequency operation using an unleveled RF source, the output level must be selected so as to obtain the in-tolerance condition across the entire band to be swept. Use slow sweep across band and set level as high as possible without exceeding allowable limit at any point in band.

d. For the oscilloscope or recorder vertical scale calibration, use single RF frequency input. Using the TIME DELAY meter as reference and the DELAY NANOSECONDS control as a means of introducing delay indications, calibrate vertical scale of oscilloscope or recorder receiving signal from OUTPUTS/TD connector to agree with meter at full scale. Check intermediate points for linearity. Calibration may be performed on any TIME DELAY RANGE NANOSECONDS scale and holds for all scales. The required sensitivity range for the

oscilloscope or recorder is 10 mv/cm with ±5 cm the nominal deflection.

e. To offset the residual delay of the system at a fixed RF frequency, adjust DELAY NANOSECONDS control to obtain zero reading on TIME DELAY meter with most sensitive TIME DELAY RANGE NANOSECONDS scale selected. For swept frequency, adjust for minimum deviation.

f. For measurement of delay with maximum accuracy in the swept mode, record residual delay versus frequency appearing at OUTPUTS/TD connector, and correct measurement data accordingly.

2-8. Measurement of Delay through Device Under Test at Fixed Frequency.

a. Insert device to be tested between Modulator Unit output and Detector Unit input.

b. Check that LEVEL meter indicates satisfactory power level. Insertion loss of test unit is limited to 10 db for full system accuracy with reference (para 2-7) power level set at maximum.

c. Select TIME DELAY RANGE NANOSECONDS setting required to obtain on-scale reading on TIME DELAY meter. Read time delay in nanoseconds directly from meter.

d. If TIME DELAY RANGE NANOSECONDS selection in step c is not most sensitive scale, an expanded scale reading is obtained as follows:

1. Note position of DELAY NANOSECONDS dial.

2. Adjust DELAY NANOSECONDS control as required to obtain on-scale TIME DELAY reading with most sensitive TIME DELAY RANGE NANOSECONDS scale selected.

3. Compute difference between DELAY NANOSECONDS dial reading obtained in step 2 and reading noted in step 1. Add this difference to TIME DELAY meter reading obtained in step 2.

2-9. Display or Recording of Delay in Swept Frequency Mode.

a. Insert device to be tested between Modulator Unit output and Detector Unit input.

b. Place METER switch in OFF position to protect TIME DELAY meter from damage.

c. Place RF source in swept mode.

d. Select TIME DELAY RANGE NANOSECONDS setting to obtain on-scale reading on oscilloscope or recorder. Read time delay in nanoseconds directly from oscilloscope or recorder.

e. Where residual time delay has been plotted, absolute time delay of device under test is obtained by subtracting residual time delay from time delay indicated through the device.

f. For expanded relative time delay across RF band swept, repeat para 2-8 (d). Scale expansion is limited, however, by the time delay excursions of the device being tested.

SECTION III
THEORY OF OPERATION

3-1. BASIC TECHNIQUE OF TIME DELAY MEASUREMENT.

The time delay instrument measures the envelope delay of an amplitude modulated, 1-MHz or 200-kHz RF signal as it is passed through the device under test. The time delay is sensed in terms of the envelope signal phase detected at the device under test output.

The phase information contained in the recovered 1-MHz or 200-kHz signal is converted to phase information at a 2-kHz rate. To accomplish this, the recovered signal is modulated at a 2-kHz rate in a balanced modulator. Two 2-kHz envelope signals are then recovered by two phase-sensitive amplitude detectors. One detector supplies the envelope of the in-phase (or 180° out-of-phase) components of the 1-MHz or 200-kHz signal, while the other detector supplies the envelope of the quadrature components of the same signal. The phase information is then contained in the relative amplitudes of the two 2-kHz detector outputs. For example, the in-phase and quadrature components are equal in amplitude for a phase shift of 45°; thus, the two detector outputs are equal in amplitude.

The phase (time delay) information, in the form of relative amplitudes, is applied to a resolver that functions as a phase shifter. This resolver provides the means of manually offsetting the input phase shift. Thus, time delay with respect to any required offset value can be measured on an expanded scale.

The resolver outputs are combined to form a 2-kHz signal whose phase with respect to the 2-kHz reference is the same as the phase of the recovered 1-MHz or 200-kHz signal with respect to the 1-MHz or 200-kHz reference, when the resolver is at the zero reference position. The positive zero crossovers of this signal are used as one switching input to a flip-flop whose opposite switching input is provided by the positive zero crossovers of the 2-kHz reference signal. Thus, the flip-flip duty cycle, and consequently the average dc value of its output, is a function of the 2-kHz signal phase with respect to the 2-kHz reference. The average dc value determines the position of the TIME DELAY meter pointer. It is also supplied to the TD output jack for use in generating a display on an oscilloscope or recorder.

3-2. BLOCK DIAGRAM DISCUSSION.

Figure 3-1 is a block diagram of the Time Delay Indicator Instruments. The external RF source provides a continuous-wave RF signal to

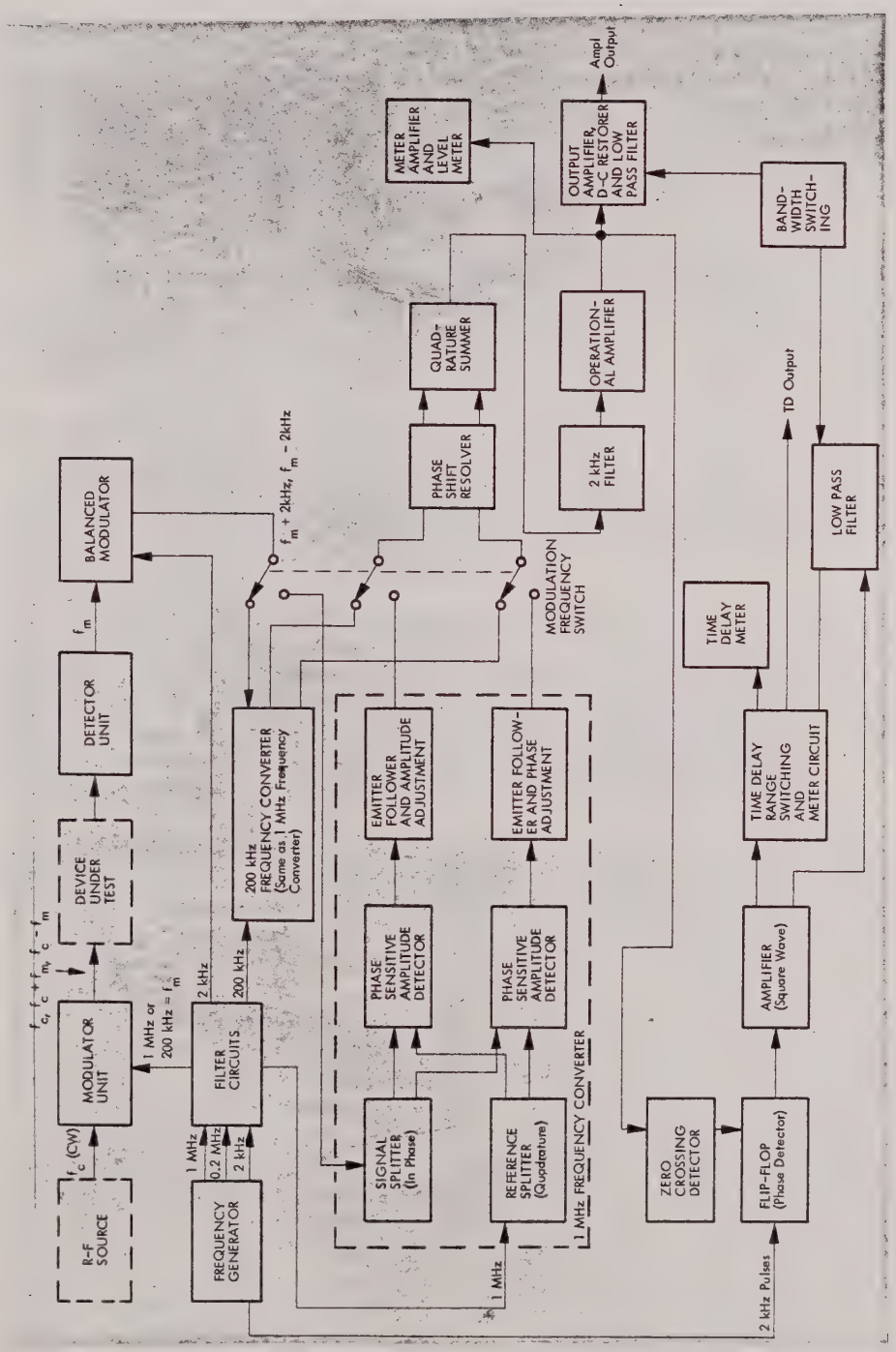


Figure 3-1. Time Delay Instruments, Detailed Block Diagram

the Modulator Unit. Within the Modulator Unit, the RF is amplitude modulated either by 1 MHz or 200 kHz, depending upon the position of the MODULATION FREQ switch. The selected modulating frequency is obtained from the frequency generator circuit via the filter circuits. A 2-MHz signal is derived from a crystal oscillator in the frequency generator circuit. This 2-MHz signal is divided down to provide various coherent square wave signals which are supplied to filter circuits where they are converted to sine waves.

The modulated RF from the Modulator Unit is applied to the device under test input; the device under test output is applied to the Detector Unit. The detector recovers the 1-MHz or 200-kHz envelope that has been shifted in phase (time) in passing through the device under test.

The Detector Unit output is applied to a balanced modulator where it is modulated at a 2-kHz rate. The 2-kHz reference for the modulator is supplied by the frequency generator circuit via the filter circuits. The balanced modulator supplies upper and lower sidebands (1 MHz + 2 kHz, 1 MHz - 2 kHz or 200 kHz + 2 kHz, 200 kHz - 2 kHz) but suppresses the carrier frequency (1 MHz or 200 kHz).

The balanced modulator output is supplied via the MODULATION FREQ switch to either the 1-MHz or 200-kHz frequency converter. Within the selected converter, the signal is split and applied to two phase-sensitive amplitude detectors. The phase reference signals for these two amplitude detectors are obtained from the phase reference splitter, which provides two reference outputs that are 90° out-of-phase with each other.

Each amplitude detector recovers the envelope of the input signal component which is in-phase (or 180° out-of-phase) with its associated reference input. Since the two reference inputs are 90° out-of-phase, the relative amplitudes of the two detector 2-kHz outputs are a measure of the signal input phase from the balanced modulator.

The two detector outputs are applied to filter circuits. In one of these circuits, the amplitude is adjustable while, in the other, the phase is adjustable. The amplitude adjustment is used to standardize the voltage scale of the two detector outputs so that amplitude differences between the two outputs are a true measure of phase. The phase adjustment is used to place the two outputs exactly in-phase as required for subsequent processing. The two filter-circuit outputs are applied, respectively, to the two input windings of a resolver that functions as a manually controlled phase shifter. When the resolver is in the zero phase shift position, the one detector output appears entirely on one output winding, while the other detector output appears entirely on the other output winding. In this case, there is no modification of the relative amplitudes of the two signals. When the resolver is placed in any

other position, cross coupling between input and output windings modifies the relative amplitudes of the outputs in relation to the relative amplitudes of the inputs as a function of the resolver angle. Thus, since the phase information is contained in the relative amplitudes, the resolver acts as a phase shifter.

The resolver outputs are applied to a quadrature summer. This circuit supplies a single output whose phase is determined by the relative amplitudes of the two inputs. When the resolver is in the zero position, the phase of the quadrature summer circuit output with respect to the 2-kHz reference is the same as the phase of the detected 1-MHz or 200-kHz envelope with respect to the 1-MHz or 200-kHz reference. The resolver provides the means for offsetting any fixed value of delay. This allows the meter to be operated on an expanded scale regardless of delay magnitude. A precision dial coupled to the resolver shaft provides data concerning the amount of offset introduced by the resolver.

The quadrature summer output is applied to a sharply tuned filter circuit. This circuit eliminates signals at other frequencies that would introduce phase distortion. The filter circuit output is applied to an operational amplifier whose output, in turn, is applied to three different circuits: the LEVEL meter circuit, the amplitude output circuit, and the zero-crossing detector circuit.

The LEVEL meter provides an indication of the signal level applied to the other two circuits. Gain of the operational amplifier is adjusted for the required level into the zero-crossing detector to achieve the specified system accuracy over the allowable range of output levels from the device under test. As long as the signal level is within the specified range, the LEVEL meter pointer is within the green tolerance band provided on the meter face.

The amplitude output circuit provides a signal whose dc level is proportional to the output level from the detector unit. This level bears an approximate square-law relationship to the output level from the device under test. The amplitude output can be applied to an oscilloscope or recorder to obtain an amplitude response display or plot of the device under test (but includes the power level variation of the RF source across the band).

The zero-crossing detector provides a positive pulse to one side of a flip-flop each time the operational amplifier output crosses zero in the positive direction. The opposite side of the flip-flop receives a positive pulse from the frequency generator circuit each time the 2-kHz reference signal crosses zero in the positive direction. Thus, the flip-flop duty cycle is determined by the phase relationship between the 2-kHz reference and the operational amplifier output. The flip-flop output is

applied via an amplifier and time delay range circuits to the TIME DELAY meter. The meter indicates the dc component of the amplified flip-flop output which, in turn, depends upon the flip-flop duty cycle. A second output from the amplifier following the flip-flop is applied via a low-pass filter and the time delay range switching circuit to the TD output connector. This output can be applied to an oscilloscope or recorder to obtain a time delay display or plot when the RF source is operated in the swept frequency mode. The bandwidth of the time delay and amplifier output circuits is controlled in accordance with the position of the BANDWIDTH switch that selects capacitive loading for these two outputs; reduced bandwidth reduces noise and is permitted for single frequency or slow sweep applications.

3-3. CIRCUIT DESCRIPTIONS.

The schematic diagrams referenced in the following paragraphs are contained in Section VI.

3-4. Power Supply.

This power supply (Figure 6-1) provides the +4.0 volts required by the logic integrated circuits in the frequency generator circuit. The 6.3-volt ac signal from the secondary of transformer T500 is full wave rectified by diodes CR501-CR504 and filtered by capacitor C500. The +4.0 volt regulated output is provided by pass transistor Q500, error amplifier Q501 referenced to the -15 volt regulated output from the master system power supply, and zener diode CR505. The output is adjusted by resistor R502.

3-5. Frequency Generator Circuit Card.

This card (Figure 6-2) derives 1-MHz, 200-kHz, and 2-kHz modulating frequencies required for Time Delay Indicator operation. These frequencies are produced by a 2-MHz crystal controlled oscillator comprising Q600, Q601, and associated circuit elements. Oscillations in this circuit are sustained through regenerative feedback from emitter follower Q600 to the emitter of Q601 via 2-MHz crystal CR600 and tuning capacitor C600.

The remaining active circuits on the frequency generator card are integrated circuit modules. The 2-MHz output from Q600 is applied to decade divider module IC601 input. Three outputs are obtained from this module: a 1-MHz output applied to a NAND gate in module IC606, a 0.4-MHz output applied to flip-flop module IC600, and a 200-kHz output applied to decade divider IC602. The 0.2-MHz output from flip-flop IC600 is applied to a second NAND gate in module IC606. When MODULATION FREQ switch S1302 is in the 1.0-MHz position, the gate receiving

the 1-MHz input from decade divider IC601 is enabled by a ground (true) level applied via contacts of the switch to its control input, and the 1-MHz output of the frequency generator is applied to the 1-MHz filter input on the filter circuit card. Similarly, when the MODULATION FREQ switch is in the 0.2-MHz position, the gate receiving the 0.2-MHz signal from the flip-flop is enabled and the 0.2-MHz signal is applied to the 200-kHz filter circuit on the filter circuit card.

The 20-kHz output from decade divider IC602 is applied to a divide-by-five circuit comprising flip-flops IC604B, IC603B, and IC604A and AND gate IC605. Flip-flops IC604B and IC603B are connected as a straight binary two-stage counter. The 20-kHz input is applied to the trigger inputs of IC604B and IC604A. Starting with a count of 000, the first count sets IC604B, and the second count resets IC604B. As IC604B resets, it sets IC603B. The third count sets IC604B. With IC604B and IC603B both set, the set gate of IC604A is enabled via AND gate IC605. Thus, the fourth count sets IC604A and resets IC604B, which in turn resets IC603B. With IC604A set, the set gate of IC604B is disabled. Thus, the fifth pulse which resets IC604A does not affect the status of IC604B. This returns the count to the initial value of 000.

The 4-kHz output from IC604A is divided down to 2 kHz by flip-flop IC603A. One output of this flip-flop is applied to the 2-kHz filter on the filter circuit card. The other output is applied via a differentiating circuit and a clamp to one side of a simple flip-flop consisting of a pair of cross-connected NAND gates on module IC606. This is the flip-flop whose duty cycle is a measure of indicated time delay and the input from IC603A is the reference switching input. The input to the opposite side of the flip-flop is the signal output from the zero crossing detector card. This is applied to the flip-flop via steering diode CR601.

3-6. Filter Circuit Card.

This card (Figure 6-3) provides three active filter circuits and a phase detector amplifier. Each filter circuit receives a square wave signal from the frequency generator circuit and supplies a sine wave output at the fundamental frequency of the input square wave. The 200-kHz filter circuit comprises tuned amplifier Q700, emitter follower output Q701, and associated circuit elements. Further frequency selectivity is provided by 200-kHz tank circuit L701 and C704. Potentiometer R729 in the base circuit of Q700 provides a level set control. The 1-MHz filter circuit comprises Q702, Q703, and associated circuit elements, and is similar in configuration to the 200-kHz filter. An input is applied at any one time to one of these two filter circuits. The output of the enabled circuit is applied to transformer T700, whose secondary is connected to the MODULATION connector. The enabled filter circuit output, taken directly from the emitter of the output emitter follower, also is applied

to the corresponding frequency converter circuit as the reference (re-inserted carrier).

The 2-kHz filter circuit comprises Q708 through Q710 and associated components. Filtering is supplied by tuned amplifier Q708, while the required drive for the balanced modulator is supplied by complementary pair driver Q709-Q710.

The phase detector amplifier comprises Q704 through Q707 and associated circuit elements. The input to this amplifier is the output from the flip-flop on the frequency generator card whose duty cycle is a measure of indicated delay. The purpose of the amplifier is to produce a waveform whose two levels are essentially the +15V and -15V power supply output levels. Transistors Q704 and Q705 in cascade provide the amplification necessary to overdrive complementary pair emitter follower Q706-Q707, as required to make Q706 and Q707 appear essentially as electronic switches that connect the output either to the +15V or -15V line. The phase detector amplifier output is applied through R733 to the time delay meter and switch circuit and through R732 to the low-pass filter in the OUTPUTS/TD connector circuit.

3-7. RF Modulator.

The RF modulator amplitude modulates the RF signal with either 0.2 or 1.0 MHz as selected by the electronic unit. A block diagram of the modulator is shown in Figure 6.4 a. The three 6-db pads shown reduce VSWR interactions. The high pass filter reduces the modulating signal from direct leakage into the measurement system. The modulator accomplishes the actual RF signal amplitude modulation. It is a balanced modulator and, therefore, requires both AC and DC signals to amplitude modulate.

Figure 6.4 b shows the details of the modulator bias network. The AC and DC signals from the electronic unit are connected to the proper levels for operation by this network. Resistor R1102 adjusts the AC level and R1103 adjusts the DC level. These adjustments are accessible through the bottom of each modulator unit.

3-8. RF Detector.

The RF detector unit is shown in Figure 6-5. The 6-db input pad reduces input VSWR and the 0.2 to 1.0 MHz preamplifier provides the required signal amplification. The preamplifier (Figure 6-5 b) located in the Detector Unit, receives the 1-MHz or 200-kHz signal from the detector. Transistors Q1 and Q2 provide necessary signal amplification. Degenerative feedback from the collector of Q2 to the emitter of Q1 via R8 stabilizes gain at approximately 26 db. Emitter follower Q3 provides the required low output impedance to drive the signal input transformer of the balanced modulator. Resistor R13 provides the 50-ohm output impedance; the maximum signal at Q3 emitter is 2 volts peak-to-peak.

3-9. Balanced Modulator.

The balanced modulator (Figure 6-6) comprises input transformer T100, diode bridge CR100 through CR103, and output transformer T101. The 1-MHz or 200-kHz signal from the Detector Unit preamplifier is applied to transformer T100 primary through series resonant circuits L102, C102 (1.0 MHz) and L103, C103 (200 kHz). The 2-kHz modulating signal from the 2-kHz filter circuit is applied between the center taps of T100 secondary and T101 primary. During one-half cycle of the 2-kHz signal, diodes CR100 and CR103 are forward biased. Under this condition, the output from terminal 1 of T100 secondary is connected to terminal 1 of T101 primary, and the output from terminal 3 of T100 secondary is connected to terminal 3 of T101 secondary.

During the other half-cycle, diodes CR101 and CR102 are forward biased, effectively reversing the connections between T100 secondary and T101 primary. Thus, the 1-MHz or 200-kHz signal appearing at T101 primary undergoes a phase inversion each time the 2-kHz signal passes through zero. At the zero crossings of the 2-kHz signal, the zero bias across all four diodes presents a high impedance between T100 and T101, effectively disconnecting the two transformers. As the 2-kHz signal approaches zero and increases after passing through zero, the non-linear portion of the forward biased diode characteristics is traversed so that amplitude modulation of the 1-MHz or 200-kHz signal is accomplished. This form of amplitude modulation, characterized by the phase reversal of the carrier (1 MHz or 200 kHz) at every zero crossover of the modulating signal, provides an output signal that contains the upper and lower sidebands but does not contain any carrier components; i.e., a double sideband, suppressed carrier signal. This signal is applied through the MODULATION FREQ switch to the selected frequency converter circuit.

3-10. 1-MHz Frequency Converter Circuit.

This card (Figure 6-7) provides the signal splitter circuit that performs an in-phase split of the signal input, the reference splitter circuit that performs a quadrature split of the reference input, and two phase sensitive detectors, each followed by a filter circuit that includes an emitter follower.

The balance modulated signal input to the circuit is applied to the splitter circuit comprising transformers T300 and T301, and associated components. It is applied to this circuit through series-resonant L300-C300 which passes the (1 MHz + 2 kHz) and (1 MHz - 2 kHz) sidebands, but discriminates against any 2-kHz component from the balanced modulator circuit.

Transformers T300 and T301 are connected in a lumped-element hybrid configuration such that the output taken from terminal 2 of T300

is equal in amplitude to, and 180° out-of-phase with, the output taken from terminal 3 of T301. These two outputs are applied through resistors R303 and R315, respectively, to the two phase-sensitive detector circuits.

The reference splitter circuit comprises transformer T302 and associated circuit elements. This circuit is designed so that the output signal taken from terminal 2 of transformer T302 leads the reference input by 45°, while the output taken from terminal 4 of T302 lags the reference input by 45 degrees. Thus, the two outputs from the circuit are equal in amplitude and 90° out-of-phase with each other.

The two reference phase splitter outputs provide the reference signals for detectors CR300 and CR301. These diodes transmit only the positive excursions of the reference. The reference is a minimum of 10 db larger than the signal input to maintain operation in the linear range.

Since the successive phase states of the signal occur at a 2-kHz rate and are 180° out-of-phase, the maximum 2-kHz amplitude modulation of one reference and, hence, detected 2-kHz, occurs when these two phase states are exactly in- and out-of-phase, respectively, with that reference. Under this signal-reference phase relationship, the 2-kHz amplitude modulation and detector output from the other reference is zero due to the additional 90° reference-signal phase relationship. As the signal undergoes a 90° phase shift, the maximum detected 2-kHz signal level from the first detector drops to zero, and the zero 2-kHz signal level from the second detector increases to a maximum. An additional 90° (total of 180°) signal phase shift shifts the maximum 2-kHz signal level back to the first detector output. The 2-kHz signal is, however, 180° out-of-phase with the 2-kHz that occurred with the original phase (0°) condition. Similarly, an additional 90° signal phase shift (290° total) shifts the maximum 2-kHz output back to the second detector output but with phase 180° with respect to the signal 90° phase condition. Therefore, the signal phase over the complete 360° range (from which time delay information is ultimately derived) is represented by the relative amplitudes of the two 2-kHz components and their phase states.

Note that the angle indicated by the relative amplitudes of the detector outputs does not coincide with the actual phase shift angle. Phasing of the two reference splitter outputs with respect to the reference input, and the two signal splitter outputs being 180° out-of-phase, causes a rotation of coordinates in the frequency converter. A further rotation of coordinates is introduced by the quadrature summer on the ZCD card. These rotations of coordinates are not significant since the phase shift resolver provides the means to compensate for them as well as the means to compensate for actual residual phase shift introduced by the measurement system. Thus, the resolver can be positioned to obtain an indicated zero time delay (0° phase shift) under reference conditions.

Capacitors C306 and C307 filter the 1-MHz components of detector CR300 by appearing as a virtual short circuit to ground for 1 MHz when compared with the detector impedance. The filtered detector output is applied to emitter follower Q300, which provides the low output impedance required to drive an input winding of the phase shift resolver. The output of Q300 is taken from the arm of AMPL ADJ potentiometer R311. This allows the path gain through detector CR300 and emitter follower Q300 to be standardized with respect to the gain through detector CR301 and emitter follower Q301, thereby obtaining relative amplitudes that are dependent only upon the input signal phase.

The filter circuit following detector CR301 is similar to that following CR300. However, it provides a means for varying phase shift rather than amplitude. Adjustment of PHASE ADJ potentiometer R319 determines the current drawn through capacitor C312, and thus determines the phase lag introduced by C312. Resistor R319 is adjusted to standardize the phase shift through the two detector-filter circuit paths. Thus, the outputs of the two emitter followers are either exactly in-phase or 180° out-of-phase, depending upon the quadrant in which the indicated phase shift angle lies. This phase relationship is necessary to obtain a correct conversion from relative-amplitude phase information to direct phase information in the quadrature summer circuit.

3-11. 200-kHz Frequency Converter Circuit.

The 200-kHz frequency converter circuit (Figure 6-8) is identical to the 1-MHz frequency converter circuit (para 3-10), except for the values of the phase-shift-determining components in the splitter circuits. These component values must differ to obtain the same phase relationships at the lower operating frequency.

3-12. ZCD Circuit Card.

This card (Figure 6-9) provides the quadrature summer, a sharply tuned 2-kHz filter, an operational amplifier, the zero-crossing detector, the LEVEL meter circuit, and the AMP output buffer.

The inputs to the card are the outputs from the two phase-shift resolver windings. These signals are either in-phase or 180° out-of-phase, depending upon the quadrant in which the indicated phase shift angle from the resolver lies. The quadrature summer converts the phase information contained in the relative amplitudes of the two inputs into direct phase information by means of a phase quadrature summation.

The required sum signal is developed in a circuit that consists of capacitor C210, PHASE potentiometer R213, and AMPL BAL potentiometer R212. The two resolver inputs are applied to this summation circuit through emitter followers Q201 and Q202, which provide the re-

quired isolation between the resolver and the summation circuit. The AMPL BAL potentiometer is adjusted to compensate for any asymmetry in gain between the two paths from the resolver to the summation circuit. PHASE potentiometer R213 is adjusted to obtain a 45° phase shift of the current through R213 and C210. Under this condition, the contributions of the two inputs to the voltage appearing at the junction of C210 and R213 are 90° out-of-phase with each other. To further clarify, consider the two limiting conditions where one voltage is at a maximum and the other voltage is zero (indicating phase shifts of 0° or 180° and 90° or 270°, respectively). If the voltage applied to R213 is zero, the voltage at the junction of C210 and R213 leads the voltage applied to capacitor C210 by 45 degrees. Conversely, if the voltage applied to C210 is zero, then the voltage at the junction of C210 and R213 lags the voltage applied to resistor R213 by 45 degrees. Thus, as the signal at one input to the summer changes from a maximum to zero (indicating a change in phase angle of 90°), a phase shift of 90° occurs at the junction of C210 and R213.

The quadrature summer output is coupled through C211 to a Darlington type emitter follower circuit comprising Q203 and Q204. This circuit presents a high input impedance to the quadrature summer to prevent phase distortion, and provides a low output impedance to drive the 2-kHz filter that follows it.

The 2-kHz bandpass filter (Rantec Part No. 05511045) is a three-pole, linear phase, 2-kHz unit with a 700-Hz, 3-db bandwidth and a voltage gain of approximately two. It provides a pure sine wave from the square wave input so that its phase can be determined from the zero crossing. A linear phase design is required so that phase distortion is not introduced into the modulator sidebands under swept frequency response tests.

The filter output is applied to an operational amplifier comprising high gain amplifier module OA201, emitter follower Q205, and associated circuit elements. The gain of this amplifier is adjusted by means of GAIN potentiometer R221, which is located in the feedback loop. In practice, this potentiometer is adjusted to obtain a 6.5-volt peak-to-peak signal at TP1301 with a 1-volt peak-to-peak input being applied to the balanced modulator.

The output of Q205 is applied via capacitor C224 and resistor R230 to output amplifier Q208, which supplies the OUTPUTS/AMP signal. Emitter follower Q208 provides isolation between the operational amplifier and the following amplifier output circuit. Rectification of amplifier Q208 output is provided by shunt diode CR205, which clips the negative excursions of the signal. The rectified output is applied to low-pass filter FL-1. The output of Q205 is also supplied via C224 and R230 to the LEVEL meter circuit. This circuit includes amplifier Q207. The output from Q207 is applied through capacitor C233 to shunt diode CR203, which rectifies by clipping negative excursions of the signal.

Positive excursions of the signal are applied through resistor R247 to shunt diode CR204. Diode CR204 presents a logarithmic characteristic to the signal to compress the signal as required for the presentation of a 20-db indication range on the meter. LEVEL METER ADJ potentiometer R248 provides a variable resistance in series with the meter. This potentiometer is set so that the meter pointer is at the right edge of the green tolerance band with 6.5 volts peak-to-peak at TP1301.

The output of Q205 is applied through capacitor C225 to the input circuit of differential amplifier OA202 of the zero crossing detector. The signal input is compared with a reference input from the slider of ZCD ZERO potentiometer R237. This is essentially a floating ground; however, it is offset slightly as required to obtain the greatest stability of time-delay indication over the required range of RF attenuation. Operated in this manner, the differential amplifier provides an essentially square wave output with the transitions of the square wave coinciding with the zero crossing of the input signal. This square wave output is amplified by Q206. The output of Q206 is differentiated by C231-R241, producing positive and negative spikes that are applied to the flip-flop circuit in the frequency generator circuit.

3-13. Meter and Switch Circuits.

This circuit (see Figure 6-10) changes the scales on the time delay meter and time delay output jack and is controlled by the front panel range pushbuttons. Resistors R811-R815 provide the precision attenuator for ranging the time delay output on the TD output jack. Resistors R807-R810 provide a constant load impedance on the driving circuit (minimum load impedance of 200k).

Resistors R800-R804 provide the precision attenuator for the time delay meter. PHASE METER ZERO potentiometer R805 is used to adjust out errors due to variation of load on the driving circuit and TRACKING potentiometer R816 is used to adjust out errors due to variation in meter impedance. SENSITIVITY potentiometer R817 is used to adjust out variation in meter sensitivities.

3-14. ET-300E Time Delay Schematic.

The major portions of the ET-300 Time Delay Instruments have been previously discussed. The remaining items will be covered in this paragraph. (Reference Section VI, Figure 6-11).

Bandwidth switch S1303 positions 1, 2, 3 provide additional filtering on the amplitude and time delay output signals on the AMP and TD output connectors. The nominal bandwidths are 175, 90, and 30 Hz, on positions 1, 2, and 3, respectively. This permits noise reduction on fixed frequency or slow sweep tests.

Low pass filters FL-1301 and FL-1302 are seven element linear phase filters with a 3-db frequency of 250 Hz and 90-db rejection at 2.0 kHz. These filters remove the 2-kHz component from the flip-flop duty cycle sensitive phase detector and pass only the DC component.

METER ON-OFF switch S1305 removes the meter and prevents damage during swept measurements when employing external data display. Resistor R1301 provides constant drive circuit load, and meter protector CR1301 provides meter electrical protection. POWER switch S1301, fuze F1301, and pilot test light DL1301 apply and indicate power to the instrument and protect against overload.

MODULATION FREQ switch S1302 configures the ET-300 Time Delay instrument for either a 200-kHz or 1.0-MHz modulation frequency. Switch S1302-D selects the desired frequency output from IC606 on the frequency generator circuit as an input to the appropriate filter circuit on the filter circuit card. Switch S1302-A applies the signal from the balanced modulator to the correct frequency converter card. Switches S1302B and S1302C select the two outputs from the correct frequency converter card as the inputs for resolver RSVR 1301. The two outputs of the resolver are the two inputs for the ZCD circuit card.

Transformer T500 provides the low AC voltage required for the 4.0-volt regulated IC power supply. BIAS switch S1306 applies the correct polarity DC bias as required by the various modulators to be used with the ET-300 Time Delay Instrument. Time Delay Range Switch S1304, in conjunction with the time delay meter and switch circuit, provides the scale expansion on the time delay meter and the time delay (TD) output connector.

SECTION IV
ALIGNMENT PROCEDURES

4-1. ELECTRONIC UNIT.

This alignment procedure requires the following equipment, or equivalent;

Electronic Counter, Hewlett-Packard Series 523

Oscilloscope, Tektronix Model 535 with Type B Plug-In

Attenuators (2); Kay Model 30
Hewlett-Packard Series 355

High Frequency Signal Generator, Hewlett-Packard Model 606A

VOM, Simpson Model 260

Cables (2), RG-55/U

Capacitor Decade, Aerovox ACD-13

Variable Inductors, Cambion 1505-2 through -8

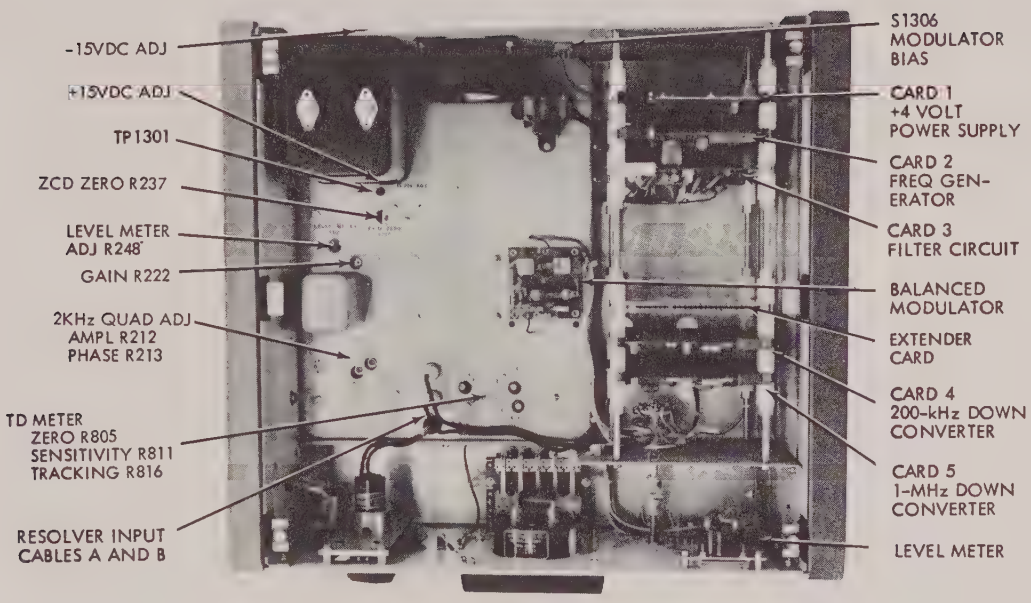
Time Delay Detector Unit, Rantec ET-300D-AB

Extender Card, Rantec 66369699

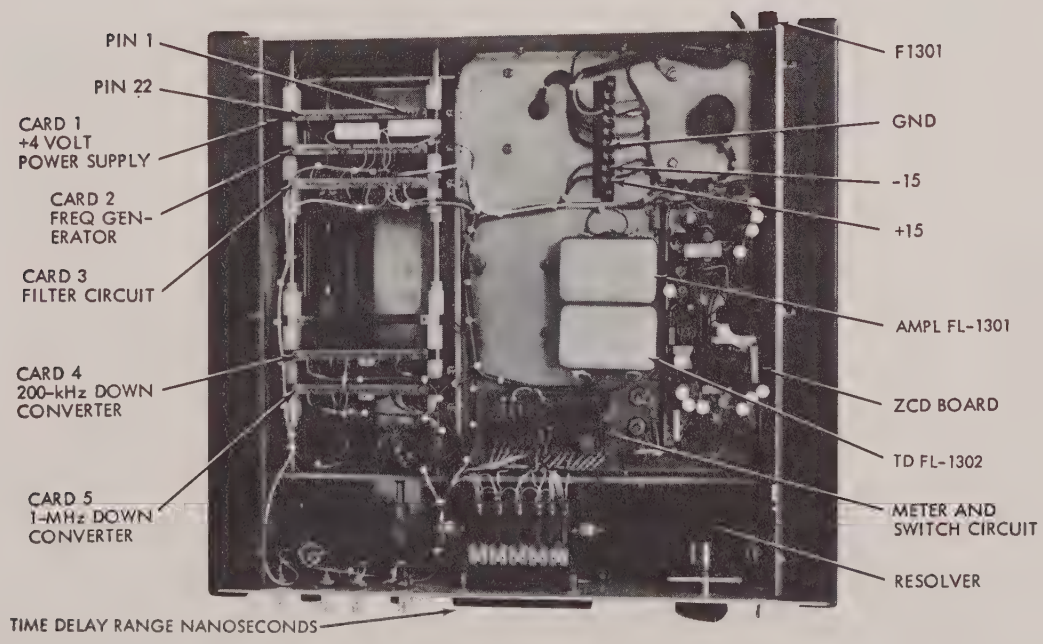
In some steps of the procedure, access is required to both the top and bottom of the unit. Thus, for convenience, the entire procedure can be performed with the top and bottom covers removed. For meter adjustments, the unit should be in the normal operating position to avoid effects of gravity on meter indications. The alignment procedure should be performed in the order in which it is presented in the following paragraphs. Figure 4-1 shows ET-300 component locations, chassis test point and adjustment locations, and circuit card, pen designations for performing the following procedures. Circuit card test points and adjustments are illustrated individually. Test point information is to be used in conjunction with the circuit diagrams contained in Section VI.

CAUTION

1. Power must not be applied to card 2 (frequency generator circuit card) until the output of the 4-volt power supply has been adjusted.



Top View



Bottom View

Figure 4-1. Electronic Unit (Model ET-300E)

CAUTION (Cont'd)

2. To avoid destruction of transistors, turn power switch to OFF to remove or replace printed circuit boards, or to attach or remove oscilloscope probes.

4-2. Power Supply Adjustments.

a. Remove frequency generator circuit (card 2). See Figure 4-1.

b. Place POWER switch in ON position and observe that POWER light illuminates.

c. Monitor +15 volt output of ±15 volt power supply (Figure 4-1), at terminal board (Figure 4-1) using VOM. Adjust +15 VDC ADJ for +15 volt output.

d. Monitor -15 volt output of ±15 volt power supply at terminal board using VOM. Adjust -15 VDC ADJ for -15 volt output.

e. Monitor +4 volt power supply output at pin 14, card connector 1, using VOM. Adjust R502 (Figure 4-2) to obtain +4 volt output.

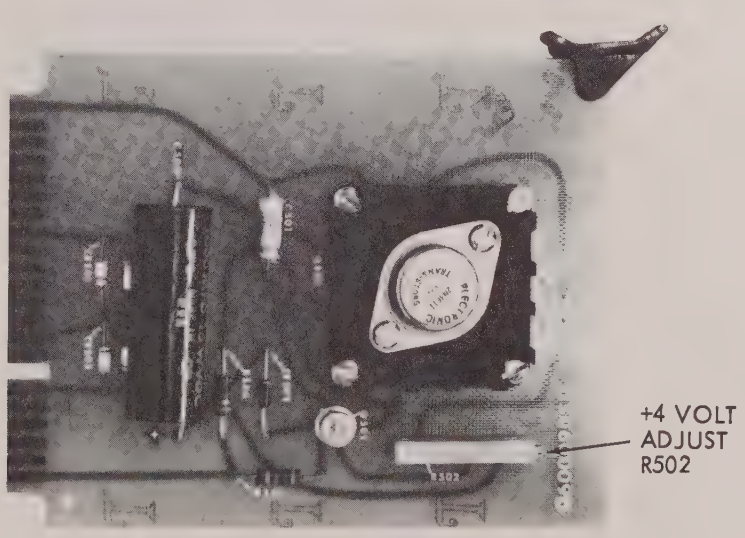


Figure 4-2. Circuit Card No. 1 (Power Supply)

f. Place POWER switch in OFF position and frequency generator card removed in step a in card connector 2.

CAUTION

For the remainder of the procedure, required manipulation of the POWER switch is not specifically called out. The switch is to be placed in the OFF position in accordance with CAUTION 2 above and returned to the ON position for each subsequent card removal or insertion.

4-3. Oscillator Frequency Adjustment.

a. Set MODULATION FREQ switch to 1.0-MHz position.

b. Monitor signal at MODULATION connector using electronic counter.

c. Adjust C600 on frequency generator (card 2) for indication of 1 MHz ±500 Hz (see Figure 4-3).

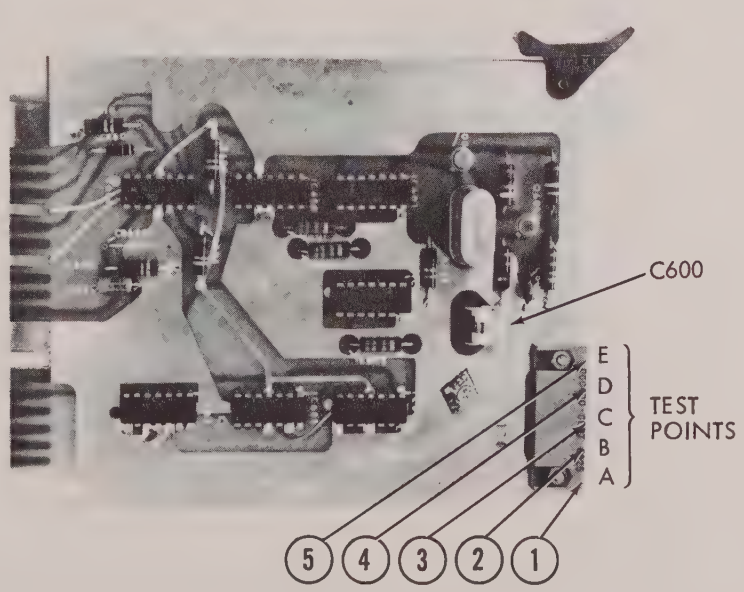


Figure 4-3. Circuit Card No. 2 (Frequency Generator Circuit)

4-4. Filter Circuit Output Levels.

a. Place filter circuit (card 3) on extender.

NOTE

The extender, furnished as part of Electronic Unit, is plugged into the connector so that the keyway in the extender mates with the key in the socket Ensure that cards 4 and 5 are inserted.

b. Observe 200-kHz filter output (pin 4, card 3 connector) on oscilloscope. (See Figure 4-1 for connector pin number assignments.)

c. Adjust R729 (Figure 4-4) on filter card to obtain 10-volt peak-to-peak amplitude.

d. Observe 1-MHz filter output (pin 2, card 3 connector) on oscilloscope.

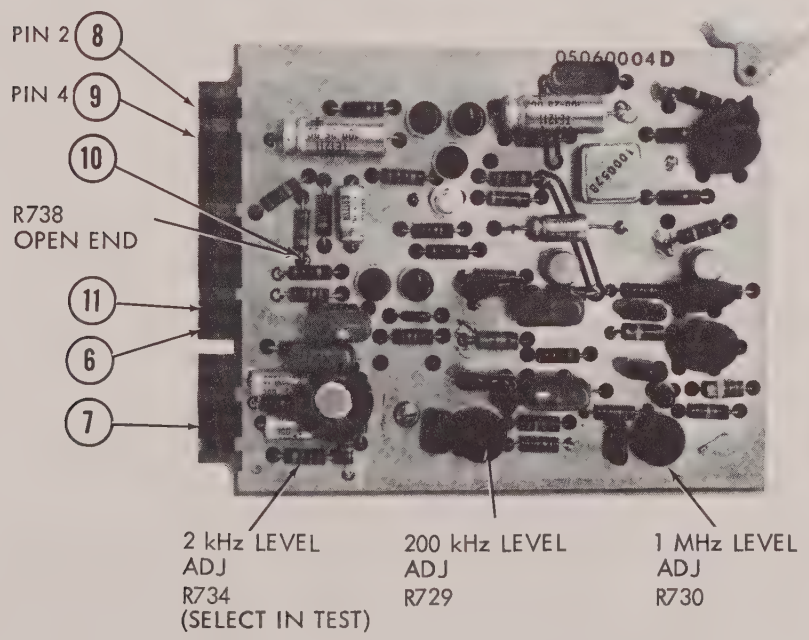


Figure 4-4. Circuit Card No. 3 (Filter Circuit)

e. Adjust potentiometer R730 on filter card (Figure 4-4) to obtain 10 volt peak-to-peak amplitude. (Little distortion should be observed.)

f. Observe 2-kHz waveform at junction of capacitor C717 and resistor on filter card.

g. Select R734 on filter card to obtain 10-volt peak-to-peak amplitude. (Little distortion should be observed.)

h. Remove filter card from extender and insert into card 3 connector.

4-5. Quadrature Summation Circuit Adjustments. (ZCD Board)

a. Using 1.0 MHz modulation frequency, connect MODULATION jack via two external attenuators (set to introduce approximately 42-db attenuation) to input of Detector Unit. Connect Detector Unit OUTPUT to Electronic Unit INPUT jack, including a BNC "T".

b. While monitoring Detector Unit output at BNC "T" on oscilloscope, set external attenuators to obtain 1.0-volt peak-to-peak amplitude. Note attenuator settings (maximum permitted input signal).

c. Observe 2-kHz waveform at TP1301 (Figure 4-1) adjusting DELAY NANOSECONDS control to maximize observed waveform. If no signal is observed, adjust GAIN control to obtain waveform (no more than 6 volts peak-to-peak in this or any subsequent step).

d. Remove knob (pull off) that couples to DELAY NANOSECONDS phase shift resolver shaft gear.

e. Connect 2-kHz signal at open end of R738 on filter circuit card 3, Figure 4-4) to horizontal input of oscilloscope.

f. Manually spin phase shift resolver rotor at a rapid rate and adjust oscilloscope gains for full-scale vertical and about 1/4-scale horizontal.

g. Increase oscilloscope vertical gain by a factor of 10 and adjust oscilloscope controls so that upper portion of lissajou pattern is visible. (See Figure 4-5).

h. Manually spin phase shift resolver rotor rapidly and observe top of resulting lissajou pattern. Compare with patterns as shown in Figure 4-5. If a "figure 8" is observed, adjust AMPL BAL control R212 (Figure 4-1 and 4-6), until it is eliminated. If top of pattern is

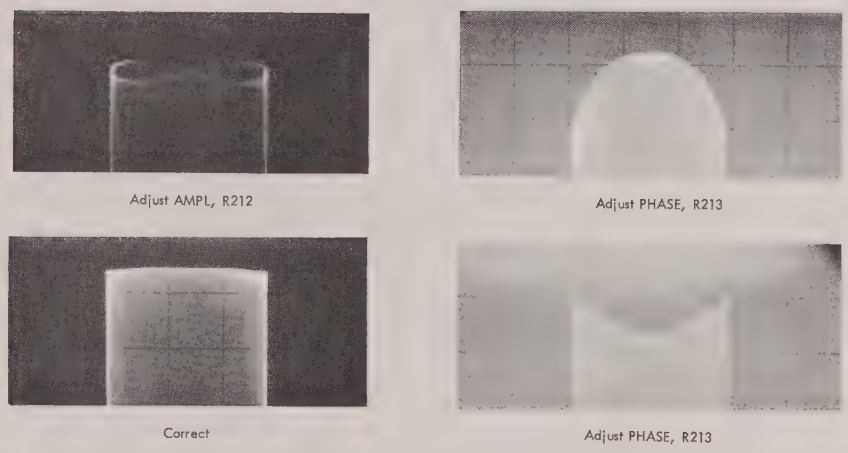


Figure 4-5. Oscilloscope Patterns, Quadrature Summation Circuit Adjustment Procedure

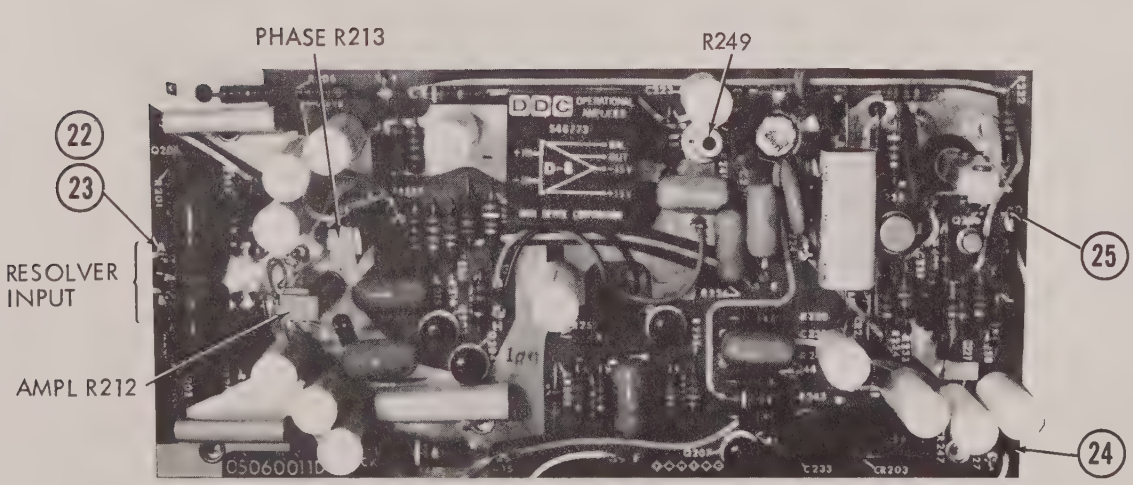


Figure 4-6. Circuit Card (ZCD Circuit)

concave and convex, adjust PHASE control R213 to obtain a straight top to pattern.

NOTE

Because of interaction between the two controls, it may be necessary to repeat both adjustments several times to obtain the straight line condition at the top of the pattern.

i. Again increase oscilloscope vertical gain by a factor of 10 (for a total increase by a factor of 100 from step g setting) and again adjust controls so that upper portion of lissajou pattern is visible.

j. Repeat step h. Final adjustment should be made with a slow manual rotation of the phase shift resolver.

k. Replace DELAY NANOSECONDS control knob.

4-6. Zero Crossing Detector Threshold Adjustment.

a. Recheck Detector Unit Output for 1 volt peak-to-peak at 1 MHz (adjust with input attenuator).

b. Check signal level at TP1301 (Figure 4-1.) Adjust GAIN control, if necessary, to obtain 6 volts peak-to-peak.

c. Set LEVEL METER ADJ control (Figure 4-1) so that LEVEL meter pointer is at right side of green band.

d. Introduce 5-db attenuation using external attenuators.

e. Adjust ZCD ZERO control (Figure 4-1) to obtain zero TIME DELAY indication with increased attenuation.

f. Remove 5-db attenuation introduced in step d.

g. Adjust DELAY NANOSECONDS control to obtain zero TIME DELAY indication.

h. Repeat steps d through g until no adjustment is required either in step e or step g.

i. Repeat steps d through h, except introduce 10-db attenuation rather than 5 db.

j. Repeat steps d through h, except introduce 20-db attenuation rather than 5 db. With 10-db attenuation introduced, LEVEL meter pointer should be at left edge of green band.

4-7. Time Delay Linearity Adjustment.

a. Adjust DELAY NANOSECONDS control to determine dial reading at which TIME DELAY indication flips between +500 and -500 nsec.

b. Turn DELAY NANOSECONDS control to dial position exactly 500 nsec from position determined in step a.

c. Adjust level of -15-volt power supply output (Figure 4-1) to obtain zero TIME DELAY indication.

d. Repeat a through c until no change is required.

4-8. Time Delay Meter Adjustments.

NOTE

The Electronic Unit must be in its normal operating orientation for this procedure.

a. Set METER switch to OFF and adjust mechanical zero of meter.

b. Set METER switch to ON.

c. With MODULATION FREQ switch in 1.0 MHz position, actuate 5 pushbutton of TIME DELAY RANGE NANOSECONDS switch and adjust DELAY NANOSECONDS control for zero TIME DELAY indication.

d. Actuate 15 pushbutton of TIME DELAY RANGE NANOSECONDS switch.

e. Adjust TD METER/ZERO control (Figure 4-1) to obtain zero TIME DELAY indication.

f. Repeat steps c through e until no adjustment is required in either step c or step e.

g. Actuate 500 pushbutton of TIME DELAY RANGE NANOSECONDS switch and adjust DELAY NANOSECONDS control for zero TIME DELAY indication.

h. Turn DELAY NANOSECONDS control CCW to introduce a change of 400 nsec in upper DELAY NANOSECONDS dial reading.

i. Adjust TD METER/SENSITIVITY control (Figure 4-1) to obtain 400-nsec indication on TIME DELAY meter.

j. Adjust DELAY NANOSECONDS control for zero TIME DELAY indication.

k. Actuate 5 pushbutton of TIME DELAY RANGE NANOSECONDS switch.

l. Adjust DELAY NANOSECONDS control for full scale (5 nsec) indication on TIME DELAY meter.

m. Actuate 15 pushbutton of TIME DELAY RANGE NANOSECONDS array. Observe reading on TIME DELAY meter.

n. Actuate 5 pushbutton of TIME DELAY RANGE NANOSECONDS array.

o. If reading observed in step m was more than 5 nsec, adjust TD METER/TRACKING control to obtain slightly greater than full scale reading on 5-nsec scale. If reading observed in step m was less than 5 nsec, adjust TD METER/TRACKING control to obtain slightly less than full scale reading on 5 nsec scale.

p. Repeat steps l through o until 5-nsec reading is obtained on both 5- and 15-nsec ranges.

4-9. Frequency Converter Quadrature Adjustments.

a. With MODULATION FREQ switch in 1.0 MHZ position, observe indications on LEVEL and TIME DELAY meters as cable A and cable B, in turn, are connected to one of the resolver input connectors with other resolver input shorted. (See Figure 4-1.) By adding capacitive reactance between the two external attenuators, obtain equal LEVEL indications and approximately in-phase TIME DELAY indications for these cable connections.

NOTE

If the signals are approximately in-phase initially, add reactance to increase the smaller of the two signals. If the signals are initially out-of-phase (as indicated by a difference in TIME DELAY indications

NOTE (Cont'd)

of approximately 500 nsec), add reactance so that the smaller of the two signals decreases, passes through zero, and then increases as the reactance is adjusted.

b. Connect cable A to resolver input being used and adjust DELAY NANOSECONDS control to obtain zero TIME DELAY indication on most sensitive scale.

c. Disconnect cable A and connect cable B. Adjust potentiometer R319 (phase adj) on 1-MHz frequency converter card (Figure 4-7) to obtain TIME DELAY indication of zero.

d. Remove shorting plug from resolver input. Connect cable A to resolver input connector A and cable B to resolver input B.

e. Connect external signal generator (H-P 606) output to Detector Unit INPUT connector (in place of test signal from MODULATION connector) via attenuators.

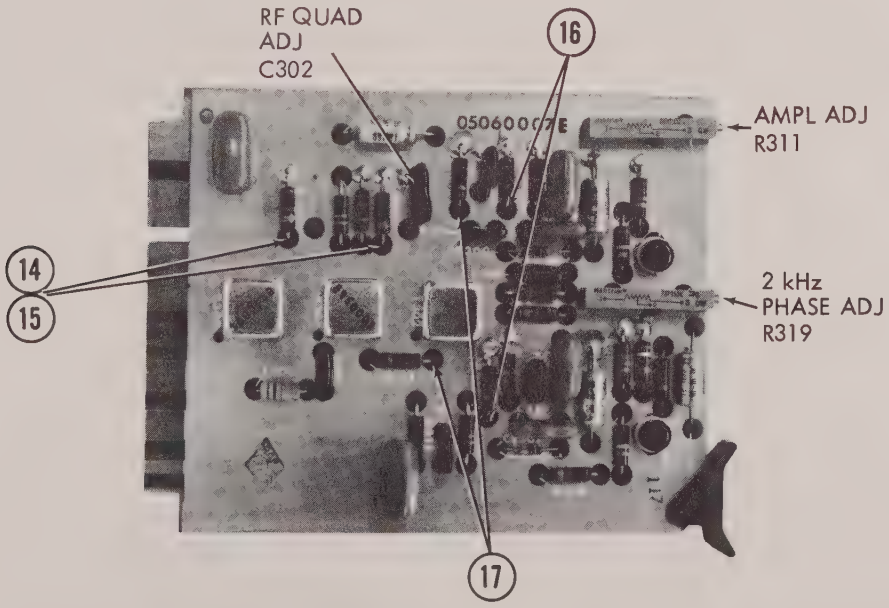


Figure 4-7. Circuit Card No. 5 (1-MHz Frequency Converter)

f. Set signal generator for 1-MHz output as observed on electronic counter and set oscillator output level for 2/3 green of level meter. (Figure 4-1.)

g. Connect 2-kHz signal at junction of C717 and R728 (Figure 4-4) on the filter circuit board to oscilloscope horizontal input.

h. Connect vertical input of oscilloscope to TP1301 (Figure 4-1).

i. Observe lissajou pattern on oscilloscope (see Figure 4-5). Offset external signal generator frequency slightly from internal 1 MHz frequency so as to obtain slowly moving oscilloscope pattern. This is a sensitive adjustment since the rate of oscilloscope pattern is the difference between internal and external 1 MHz frequencies.

j. Adjust oscilloscope gain controls to obtain full scale vertical deflection and approximately 1/4 scale horizontal deflection of pattern.

k. Increase oscilloscope vertical gain by a factor of 10 and adjust vertical position control so that upper portion of lissajou pattern is visible.

l. Attempt to obtain straight line condition at top of pattern by adjusting R311 (amplitude adj) on 1 MHz frequency converter card (see Figures 4-5 and 4-7).

NOTE

This should normally be possible unless it has been necessary to replace a transformer or capacitor in one of the signal or load oscillator splitter circuits on the card. In this case, the value of capacitor C302 may have to be adjusted to obtain the flat pattern.

m. Again increase oscilloscope vertical gain by a factor of 10 (for a total increase of a factor of 100 from the initial full-scale setting of step k).

n. Repeat step l.

o. Repeat steps a through n as necessary to compensate for any initial interaction between setting in steps c and l.

p. Place MODULATION FREQ switch in the 0.2 MHZ position.

q. Repeat steps a through o (with MODULATION FREQ switch as placed in step p) except:

In step c, adjust R419 on 200 kHz frequency converter card (Figure 4-8)

In step e, set external signal generator for 200 kHz

In step l, adjust R411 on 200 kHz frequency converter card

4-10. Readjustment of Zero Crossing Threshold and System Gain.

a. Connect MODULATION connector via two external attenuators (set to introduce 42 db of attenuation) and Detector Unit to INPUT connector.

b. Observe signal level at TP1301 (Figure 4-1) with MODULATION FREQ switch in both positions and external attenuation adjusted in each case for 1.0 volt peak-to-peak at Detector Unit output.

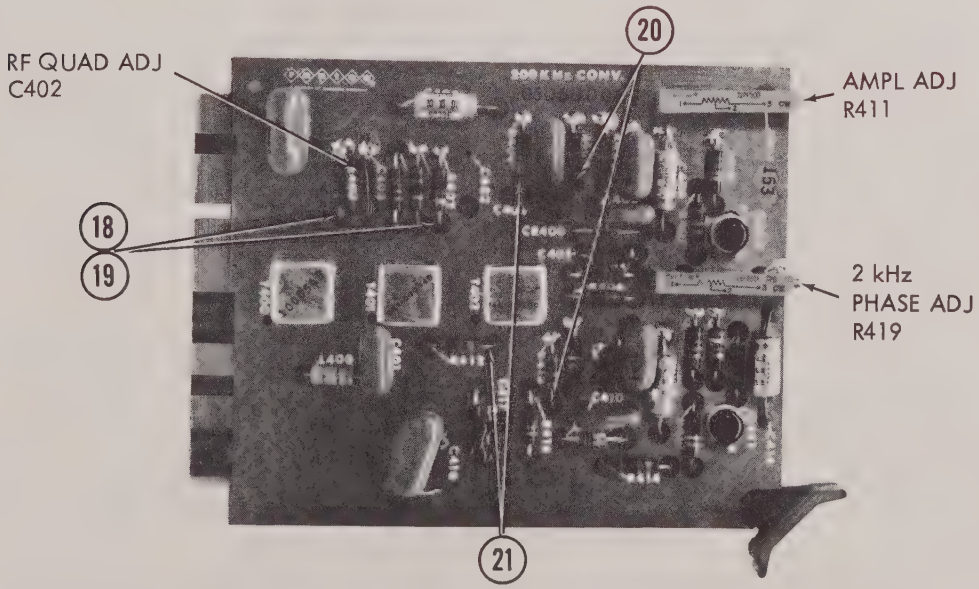


Figure 4-8. Circuit Card No. 4 (200-kHz Frequency Converter)

c. Place MODULATION FREQ switch in position where weaker signal was observed in step b with external attenuation adjusted for 1.0-volt peak-to-peak at Detector Unit output.

d. Adjust gain for 6-volts peak-to-peak at TP1301.

e. Place MODULATION FREQ switch in 1.0-MHz position and adjust input level (external attenuation) for 6-volts peak-to-peak at TP1301.

f. Repeat step j of para 4-6.

g. Place MODULATION FREQ switch in 0.2-MHz position.

h. Repeat step j of para 4-6 except that no adjustment of ZCD ZERO control should be required.

4-11. RF MODULATOR UNITS.

a. Connect Modulator Unit output to Detector Unit input covering same frequency range.

b. Connect detector output to INPUT connector of Electronic Unit.

c. Connect MODULATOR output connector of Electronic Unit to modulation input of Modulator Unit.

d. Connect source of CW RF at 10-mw level and at frequency within range of Modulator Unit to RF input of Modulator Unit.

e. Set MODULATION FREQ switch on Electronic Unit to 1.0-MHz position.

f. Set modulator bias switch S1306 (Figure 4-1) to position indicated on modulator being used.

g. Set level of external RF source to position LEVEL indicator pointer on Electronic Unit at left edge of green band.

h. Adjust DC control in Modulator Unit (Figure 4-9) to obtain maximum indication on LEVEL meter.

i. Adjust AC control in Modulator Unit to obtain maximum indication on LEVEL meter (repeat steps h and i).

j. Adjust level of external RF source to position pointer of LEVEL indicator on Electronic Unit at center of green band.

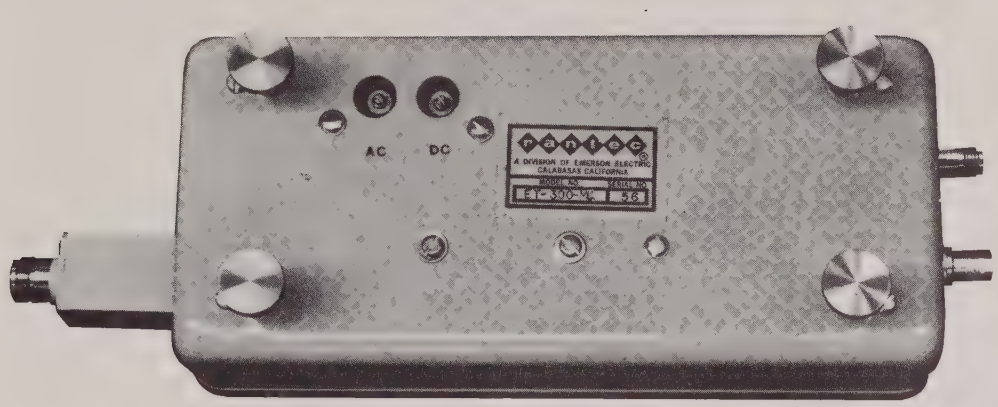


Figure 4-9. Modulator Unit

k. Place external RF source in swept mode to sweep one octave within range of Modulator Unit.

l. If necessary, adjust level of external RF source so that LEVEL indication remains within green band during sweep.

m. Adjust AC control in Modulator Unit to minimize residual time delay variation as observed on TIME DELAY meter with TIME DELAY RANGE NANOSECONDS 5 pushbutton depressed if residual variation is more than 2 nsec. No more than 2-db loss in system sensitivity should be incurred by this adjustment.

SECTION V
MAINTENANCE

5-1. FAULT LOCATION.

The majority of faults can be described in terms of the LEVEL and TIME DELAY indications and the effect on these indications of moving the DELAY NANOSECONDS control or changing the position of the MODULATION FREQ switch. The chart that follows lists various abnormal combinations of indications, indicates the probable locations of the source of the fault, and in some cases indicates a specific remedial action. In most cases, localization of the fault to one of several indicated sources is most easily accomplished by observing waveforms associated with these circuits. Observed waveforms should be compared with the typical waveforms for a normally operating unit (para 5-2).

Refer to the equipment schematic (Section VI, Figure 6-11) as an aid in troubleshooting.

Malfunction	Cause/Remedy
POWER indicator does not light when POWER switch is placed in ON position.	Fuze, F1301, blown; replace, if necessary. If fuse blows again, trouble in ±15-volt or +4-volt power supply is indicated.
	Lamp DL1301 defective; replace, if necessary. Input power off.
TIME DELAY meter at zero with POWER indicator lighted and no R-F power input.	Defective component in meter circuit or transistors, Q706, and Q707, on filter circuit card open circuited.
TIME DELAY meter at full positive delay position with no R-F input.	Defective component in phase detector amplifier on filter card or defective component in frequency generator circuit.
Variation in LEVEL indication rather than in TIME DELAY indication when DELAY NANOSECONDS control is moved.	Check for defective Q201, Q202, or associated circuit element, or defective resolver output winding.

Malfunction	Cause/Remedy
LEVEL indication normal, TIME DELAY indicator remains at negative full scale regardless of position of DELAY NANOSECONDS control.	Defective element in phase detector amplifier on filter circuit card. Defective flip-flop on frequency generator card. Defective zero crossing detector circuit component.
Normal TIME DELAY response but no LEVEL indication.	Defective component in LEVEL meter circuit on ZCD circuit card.
TIME DELAY indicator remains at negative full scale and LEVEL indicator remains at zero with normal R-F input and with MODULATION FREQ switch in 1.0 MHZ position. Indications are normal for 0.2 MHZ position.	Defective component in signal or reference splitter circuit on 1-MHz frequency converter board. Defective component in 1-MHz filter circuit on filter circuit card. Defective 1 MHz gate circuit on frequency generator card.
TIME DELAY indicator remains at negative full scale and LEVEL indicator remains at zero with normal R-F input and with MODULATION FREQ switch in 0.2 MHZ position. Indications are normal for 1.0 MHZ position.	Defective component on signal or reference splitter circuit on 200 kHz frequency converter board. Defective components in 200-kHz filter circuit on filter circuit card. Defective 200-kHz gate circuit on frequency generator card.
TIME DELAY indication is normal but no signal appears at OUTPUTS/TD connector	Defective component in meter switching circuit, BANDWIDTH switching circuit, associated filter, or defective R732 on filter circuit card.
Normal TIME DELAY indication but no signal at OUTPUTS/AMP connector.	Defective Q208 or associated circuit element, defective filter, or short circuit in BANDWIDTH switching circuit.
TIME DELAY indicator remains at negative full scale and LEVEL meter remains at zero with normal input level to modulator unit for either position of MODULATION FREQ switch.	Fuse F100 blown. Replace, if necessary. Defective component in Detector Unit or Modulator Unit if 1 volt peak-to-peak cannot be obtained at input to balanced modulator. Defective component in balanced modulator. Defective component in frequency generator circuits. Defective component in 2-kHz filter circuit.

Malfunction	Cause/Remedy
	Defective Q203, Q204, operational amplifier, OA201, Q205, or associated circuit element on ZCD circuit board. Defective component in +4-volt power supply.

5-2 WAVEFORMS.

Waveforms, photographed at significant test points in a normally operating Time Delay Indicator Instrument, are provided in Section VI. Waveforms were obtained using a Tektronix 535A oscilloscope with a 53/54C plug-in unit set for AC input and a 10X probe. All waveforms dependent upon the application of an input signal to the INPUT connector were taken under the following conditions: The MODULATION connector was connected via external attenuators and Detector Unit to the INPUT connector and the external attenuators were set so as to obtain 1 volt peak-to-peak at the Detector Unit output. The oscilloscope was internally triggered except for waveforms where trigger signals are listed.

Voltage and time base scales and other significant conditions are listed for individual waveforms. Voltage scales include the effect of the probe attenuation.

Test point locations are indicated on the schematics in Section VI. Photographs depicting the physical location of test points and adjustments are contained in Section IV. Test points on schematics have been numbered for convenience and are keyed to the illustrations contained in Section IV.

SECTION VI
CIRCUIT DIAGRAMS

Figures 6-1 through 6-10 are schematic diagrams of the individual Time Delay Instruments electronic circuits. Figure 6-11 is the over-all system schematic.

Sequential test point numbers have been assigned for convenience and arenot physically located on the equipment. Physical location of the test points shown in Figures 6-1 through 6-10 are contained in Section IV, Alignment Procedures.

A detailed breakdown of the electrical components comprising the ET-300E System is given in Section VII, Illustrated Parts Breakdown.

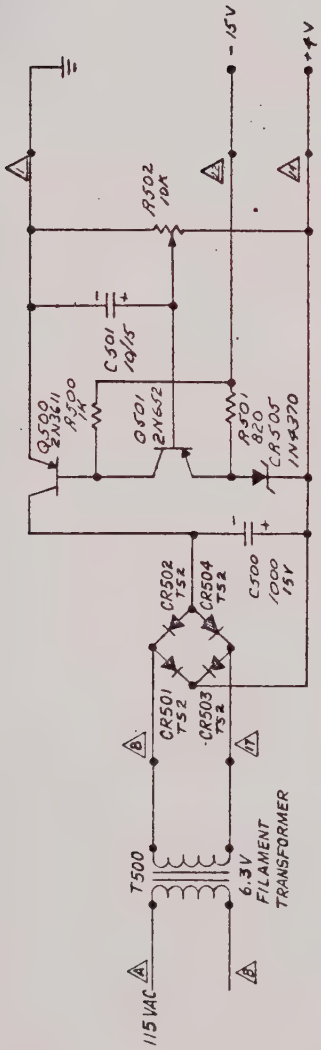


Figure 6-1. Power Supply Schematic Diagram

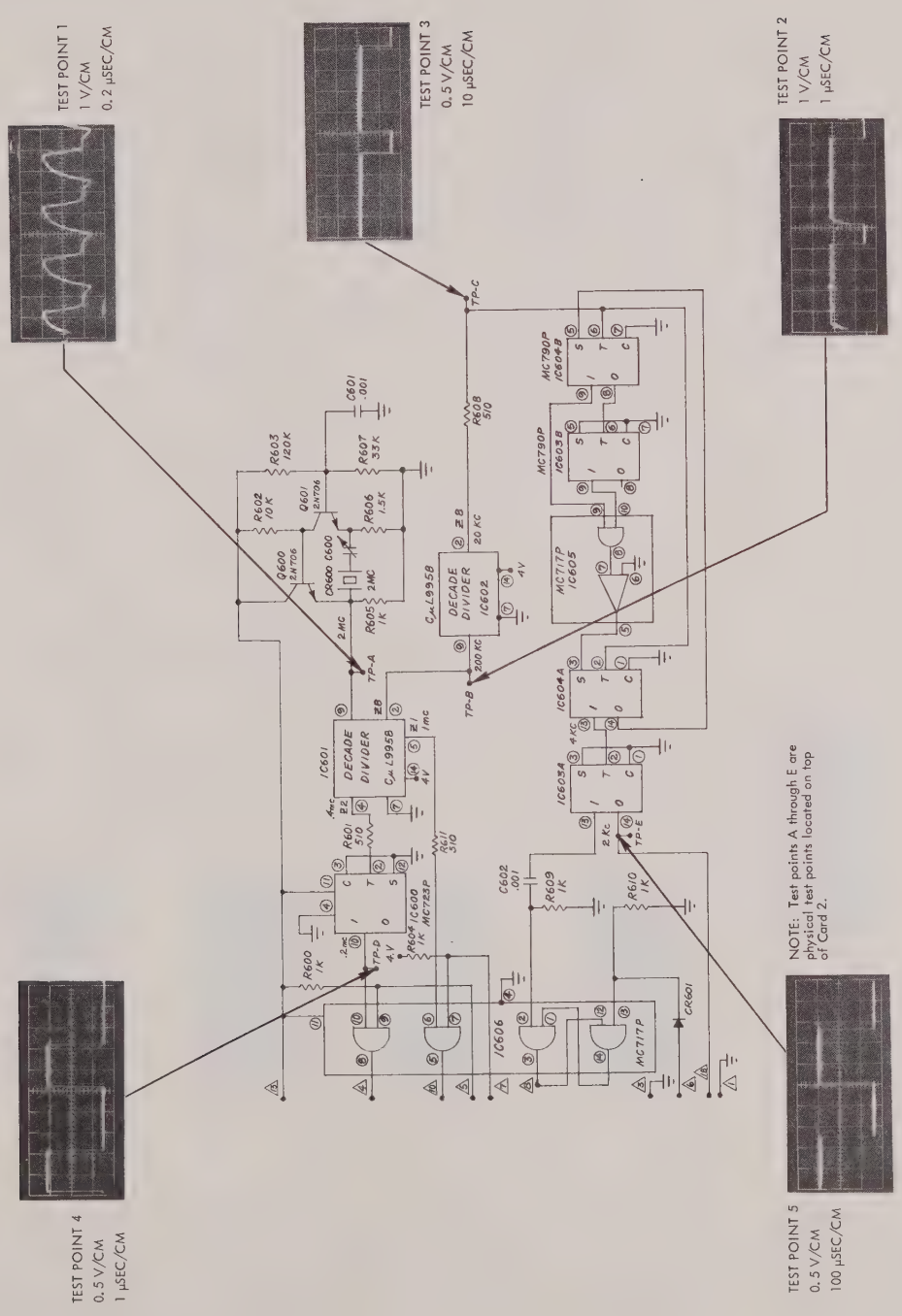


Figure 6-2. Frequency Generator Circuit Schematic Diagram

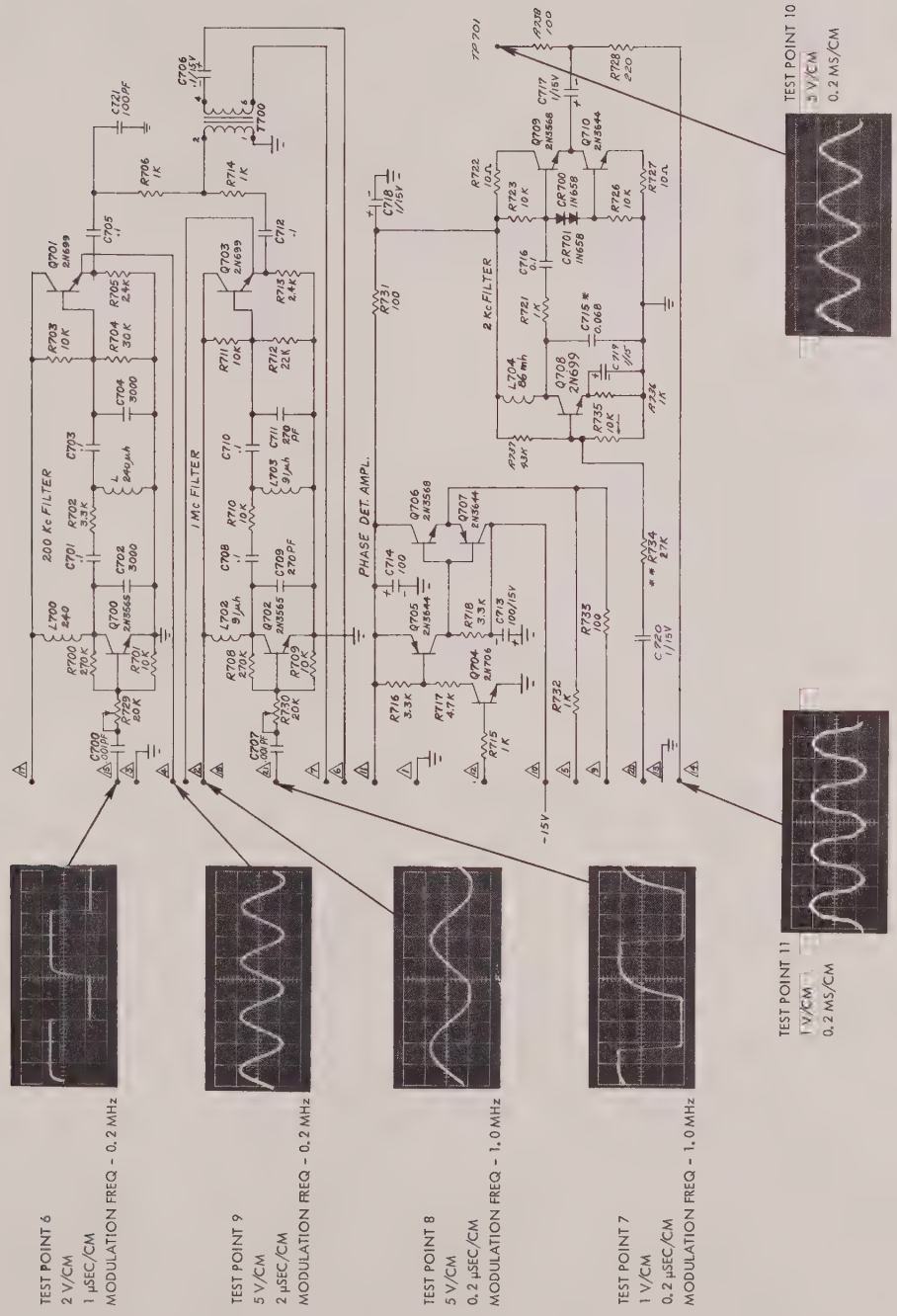
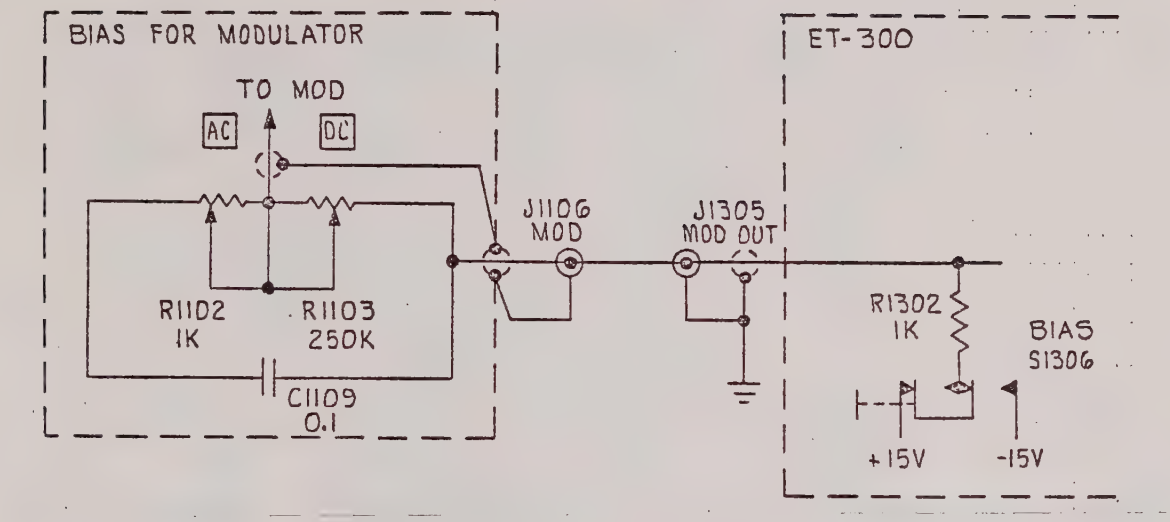
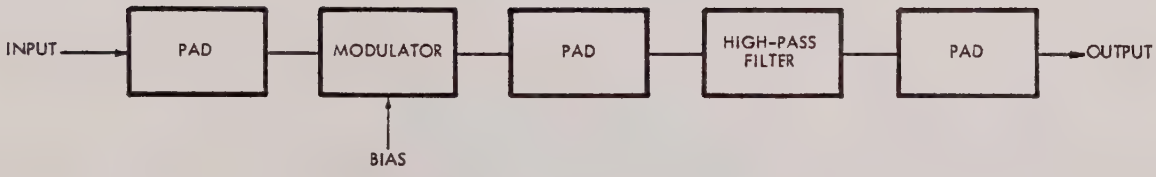


Figure 6-3. Filter Circuit Schematic Diagram

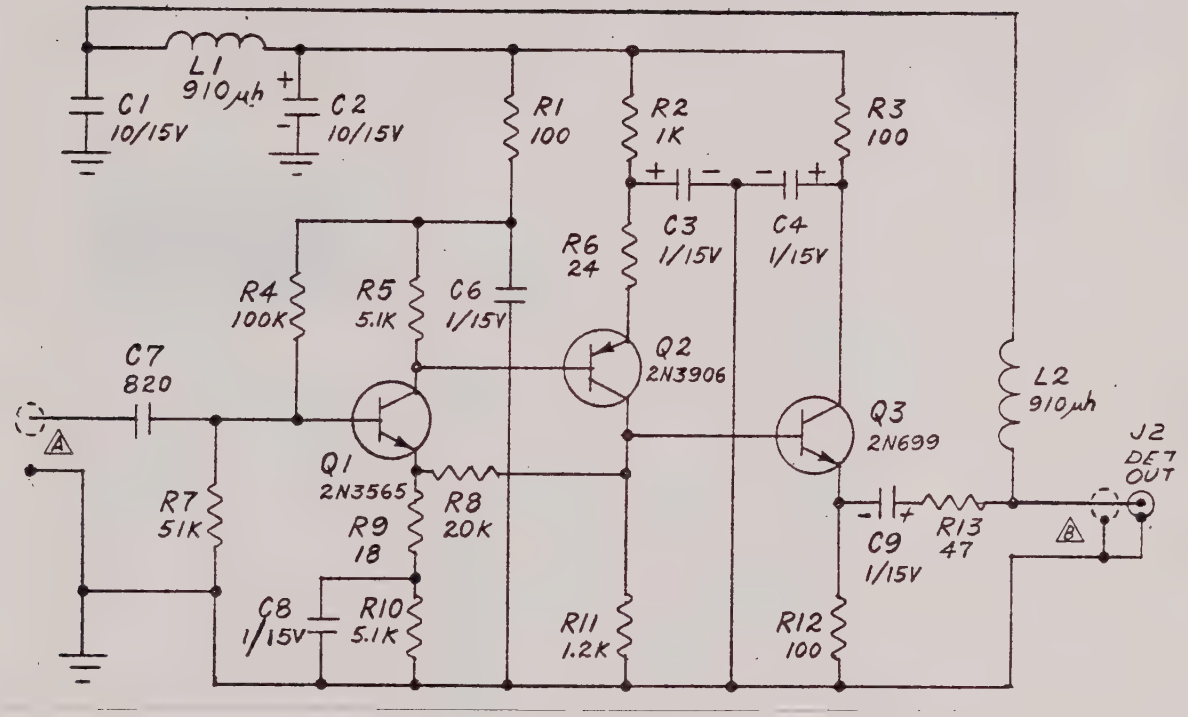


Modulator Bias Network

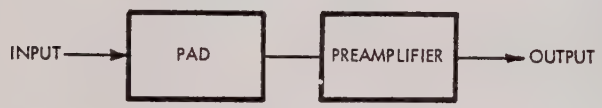


Block Diagram

Figure 6-4. Time Delay Modulator



Detector Preamplifier



Block Diagram

Figure 6-5. Time Delay Detector

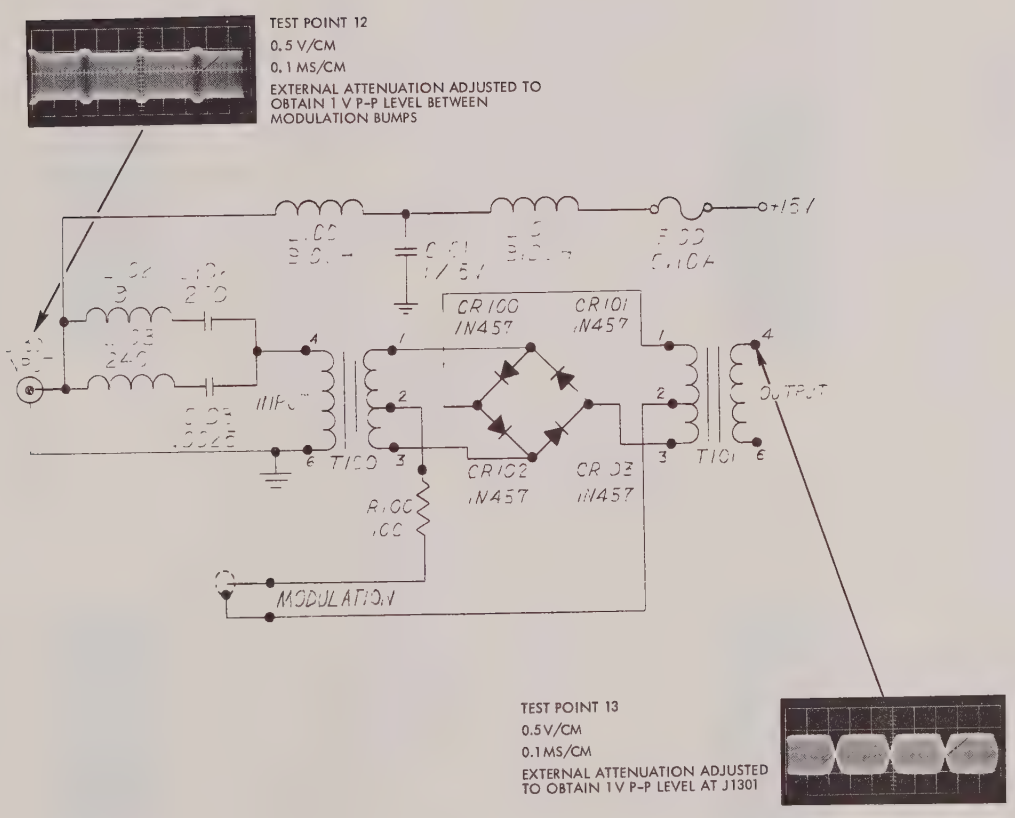


Figure 6-6. Balanced Modulator Schematic Diagram

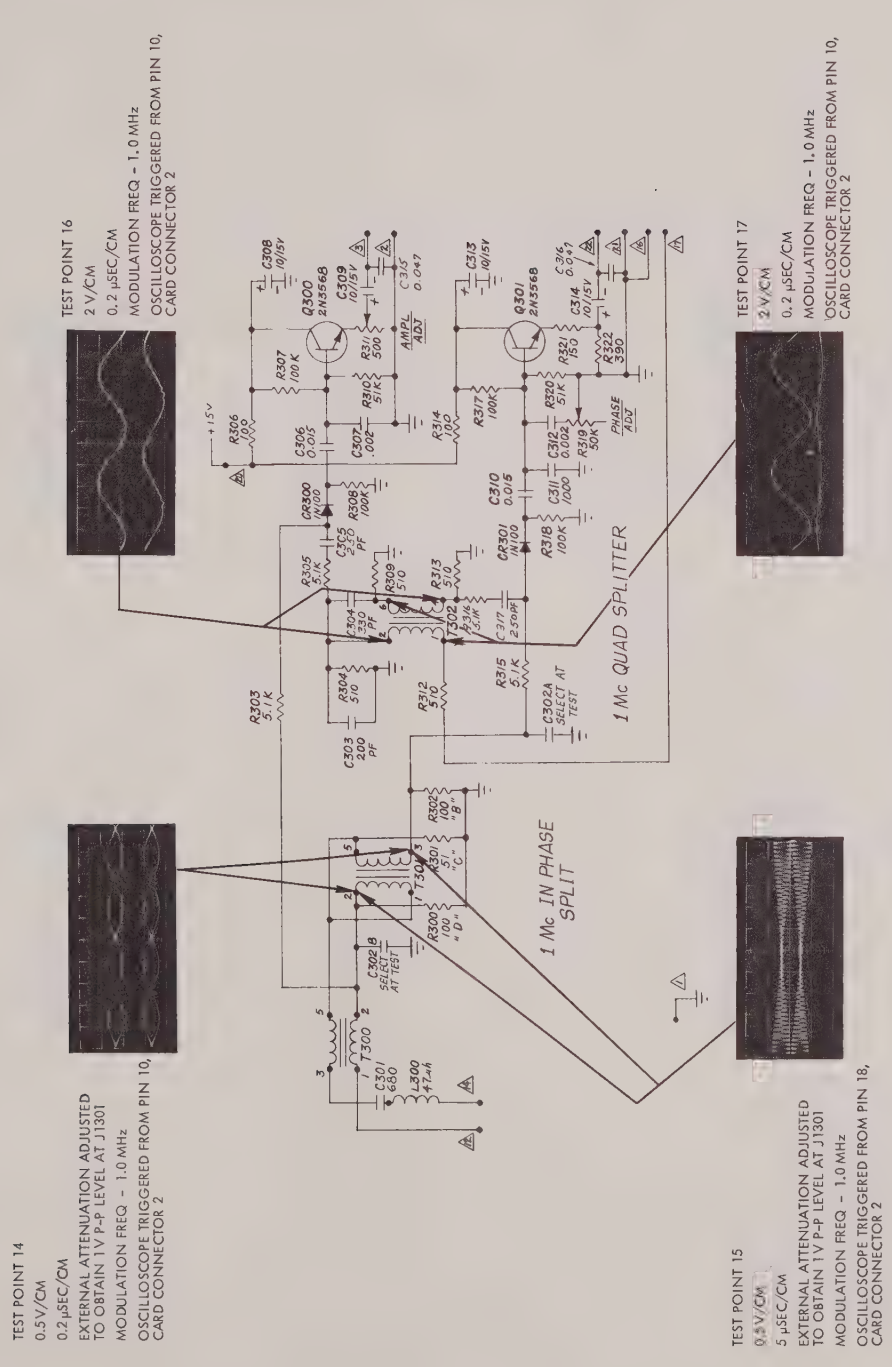


Figure 6-7. 1-MHz Frequency Converter Schematic Diagram

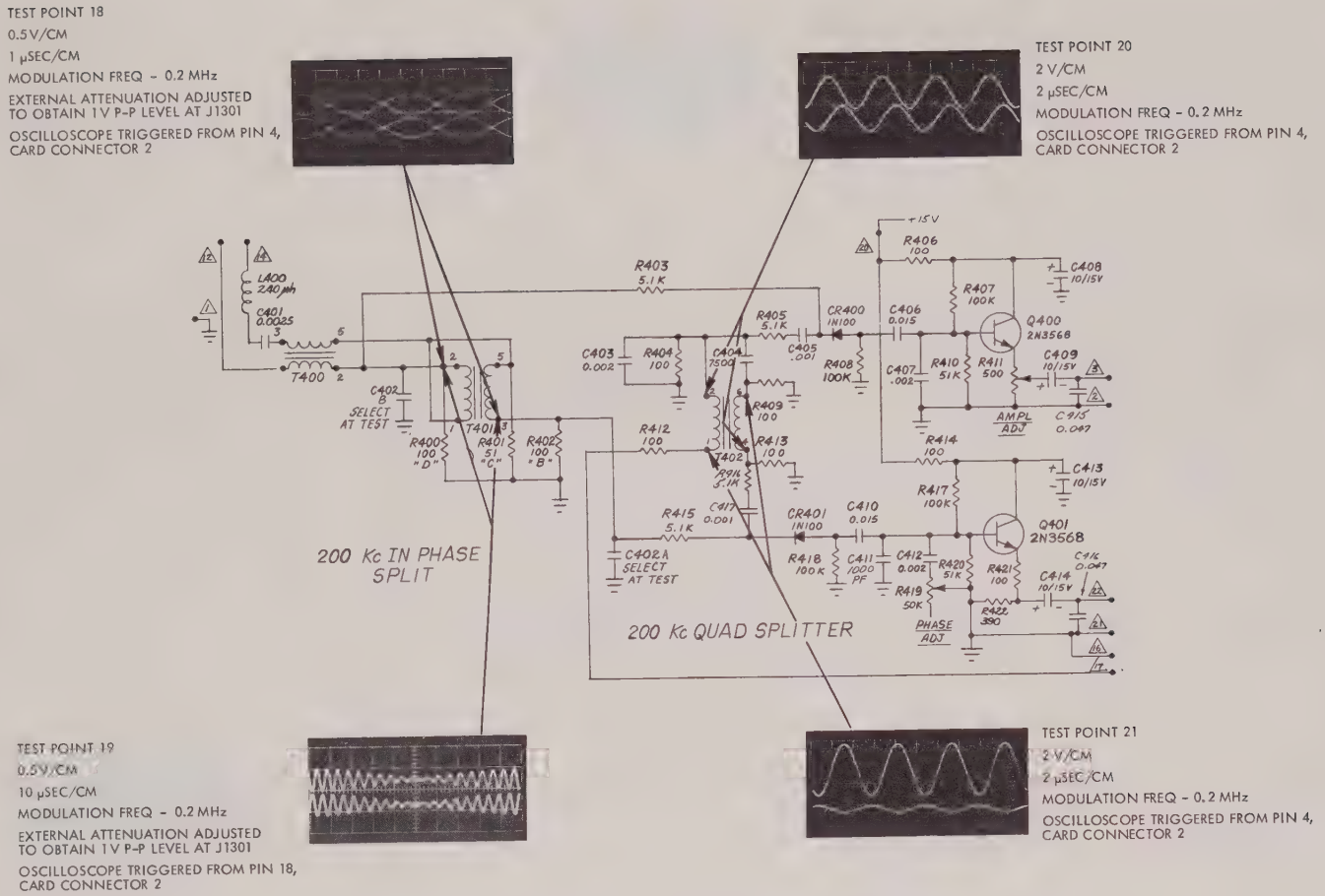


Figure 6-8. 200-kHz Frequency Converter Schematic Diagram

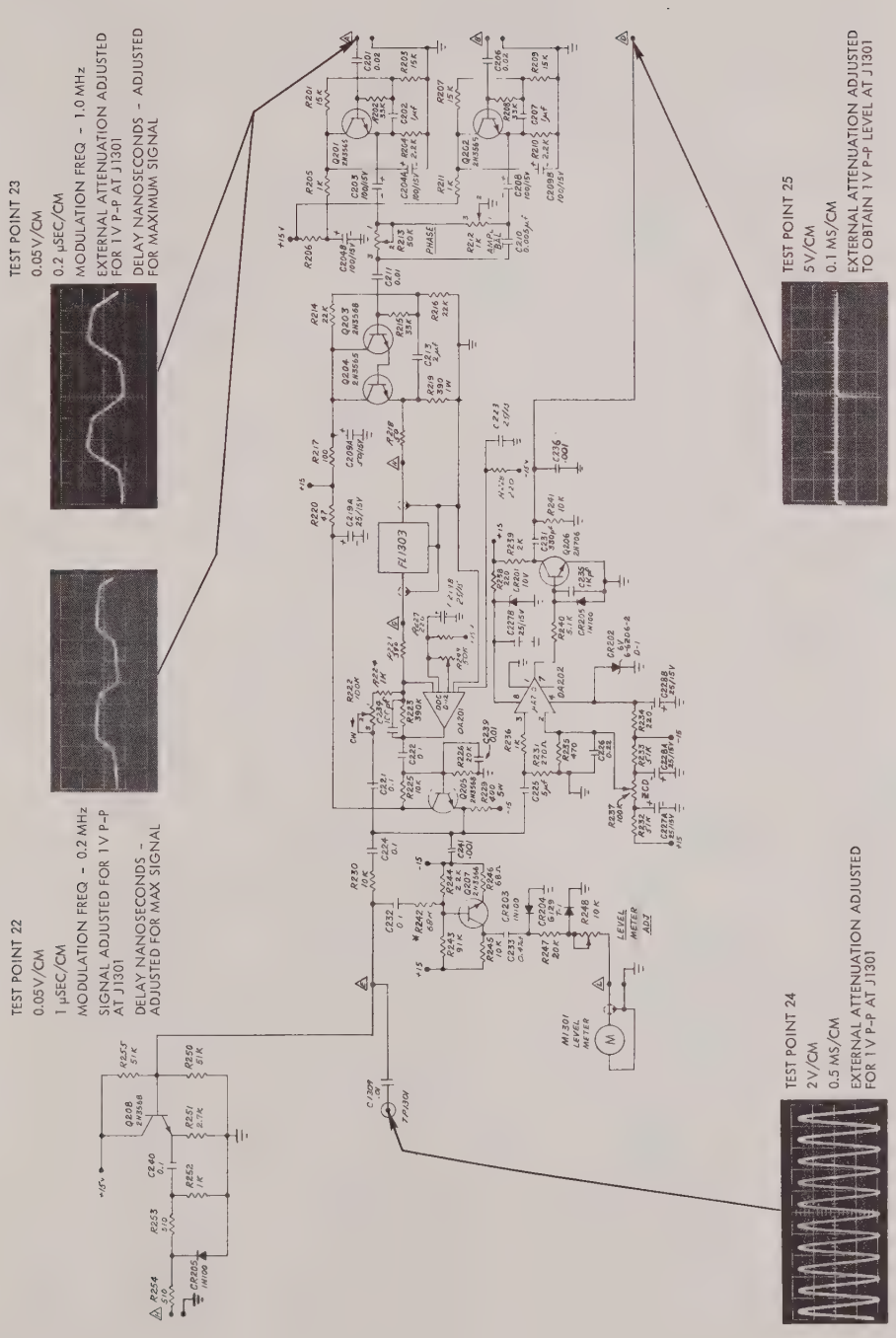

TEST POINT 23
0.05 V/CM
0.2 μSEC/CM
MODULATION FREQ - 1.0 MHz
EXTERNAL ATTENUATION ADJUSTED FOR 1 V P-P AT J1301
DELAY NANOSECONDS - ADJUSTED FOR MAXIMUM SIGNAL
TEST POINT 22
0.05 V/CM
1 μSEC/CM
MODULATION FREQ - 0.2 MHz
SIGNAL ADJUSTED FOR 1 V P-P AT J1301
DELAY NANOSECONDS - ADJUSTED FOR MAX SIGNAL
TEST POINT 25
5 V/CM
0.1 MS/CM
EXTERNAL ATTENUATION ADJUSTED TO OBTAIN 1 V P-P LEVEL AT J1301
TEST POINT 24
2 V/CM
0.5 MS/CM
EXTERNAL ATTENUATION ADJUSTED FOR 1 V P-P AT J1301
PHASE
LEVEL METER ADJ
M1301 LEVEL METER
RJ303

Figure 6-9. ZCD Circuit Schematic Diagram

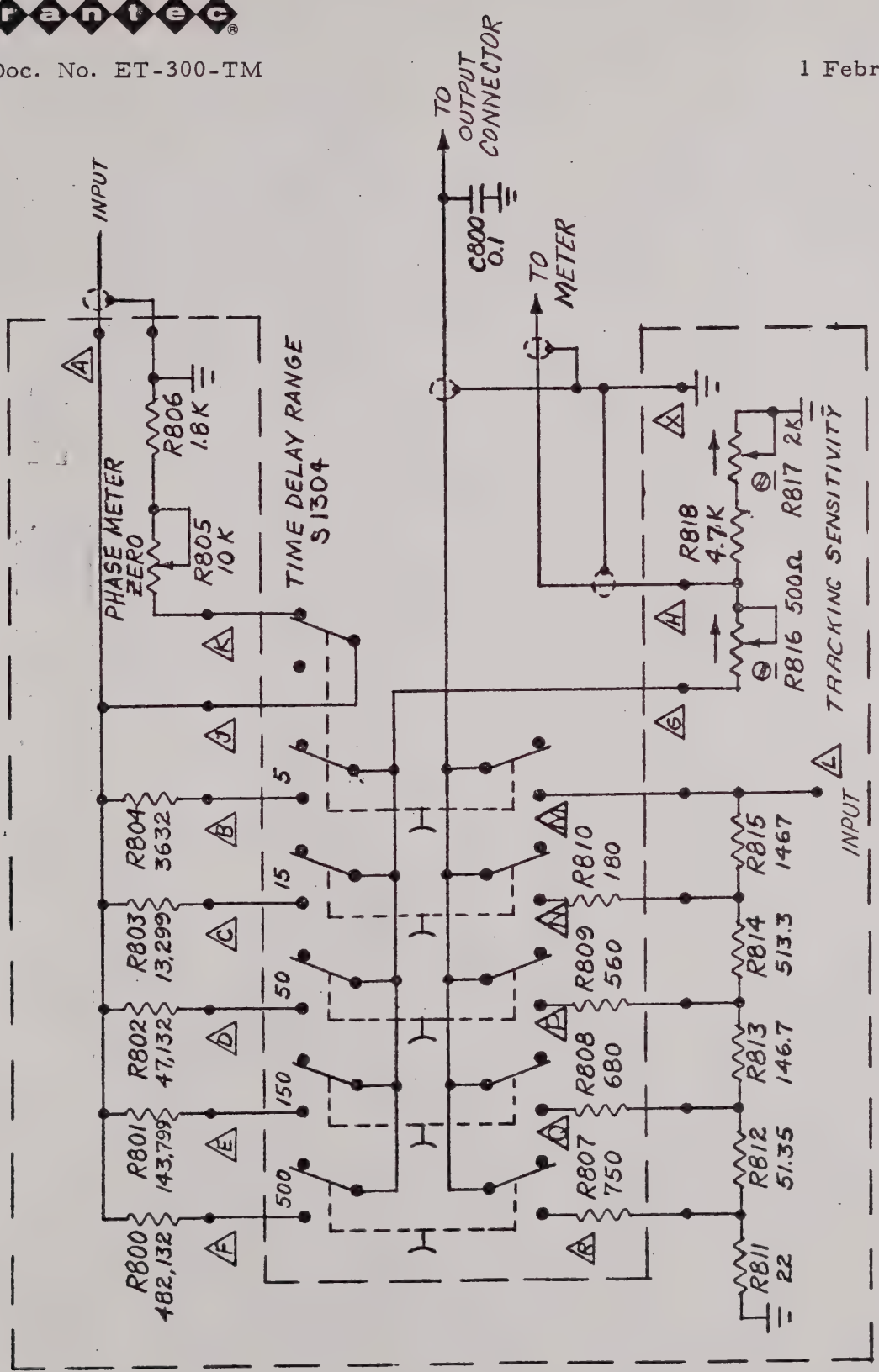
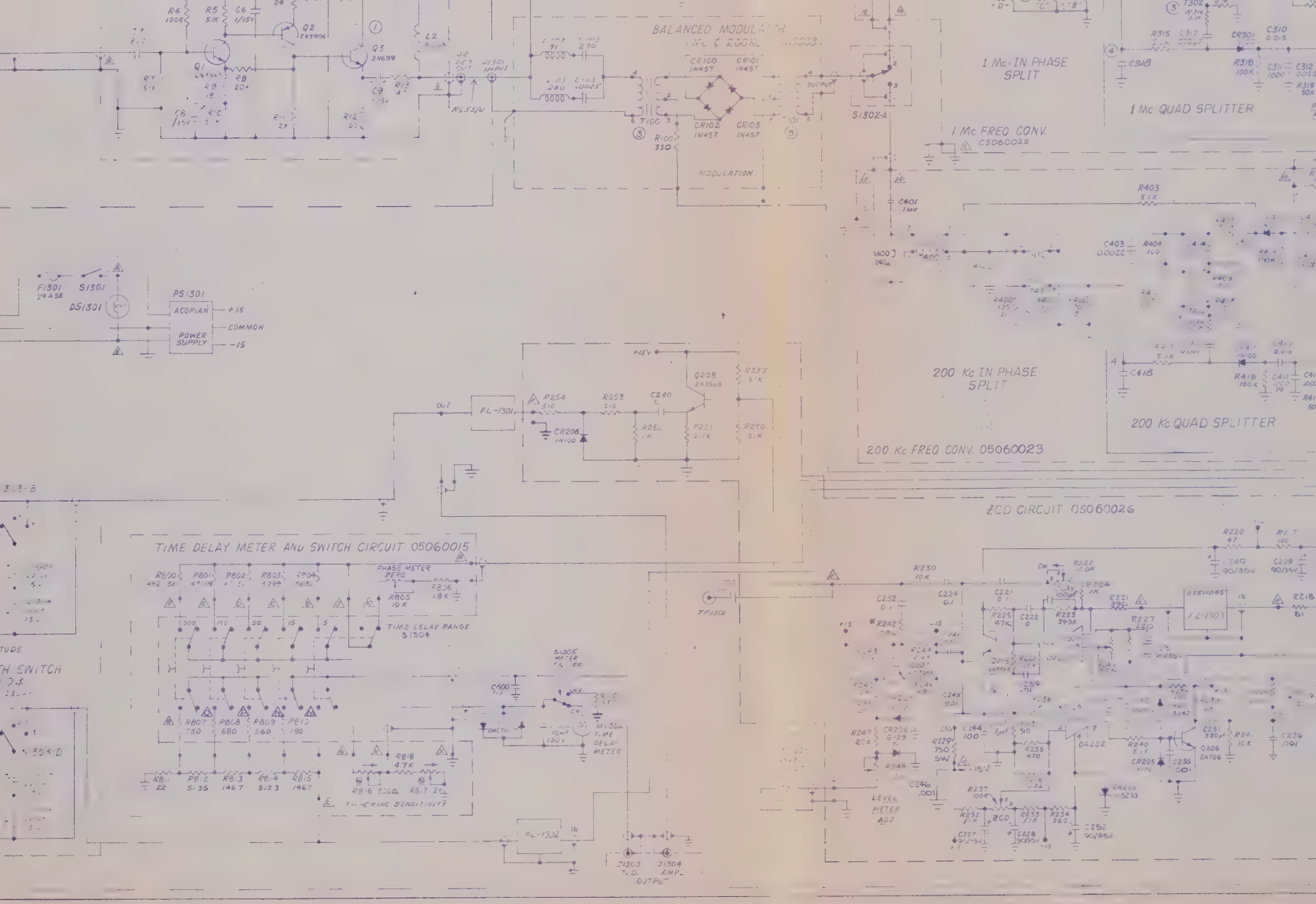


Figure 6-10. Meter and Switch Circuit Schematic Diagram


BALANCED MODULATOR
MODULATION
1 Mc IN PHASE SPLIT
1 Mc QUAD SPLITTER
1 Mc FREQ CONV. C5060022
200 Kc IN PHASE SPLIT
200 Kc QUAD SPLITTER
200 Kc FREQ CONV. 05060023
ZCD CIRCUIT 05060026
TIME DELAY METER AND SWITCH CIRCUIT 05060015
PS1301
ACOPIAN POWER SUPPLY
+15
COMMON
-15
FL-1301
TIME DELAY RANGE S1304
TIME DELAY METER
LEVEL METER ADJ
J1303 T.D. OUTPUT
J1304 AMP. OUTPUT

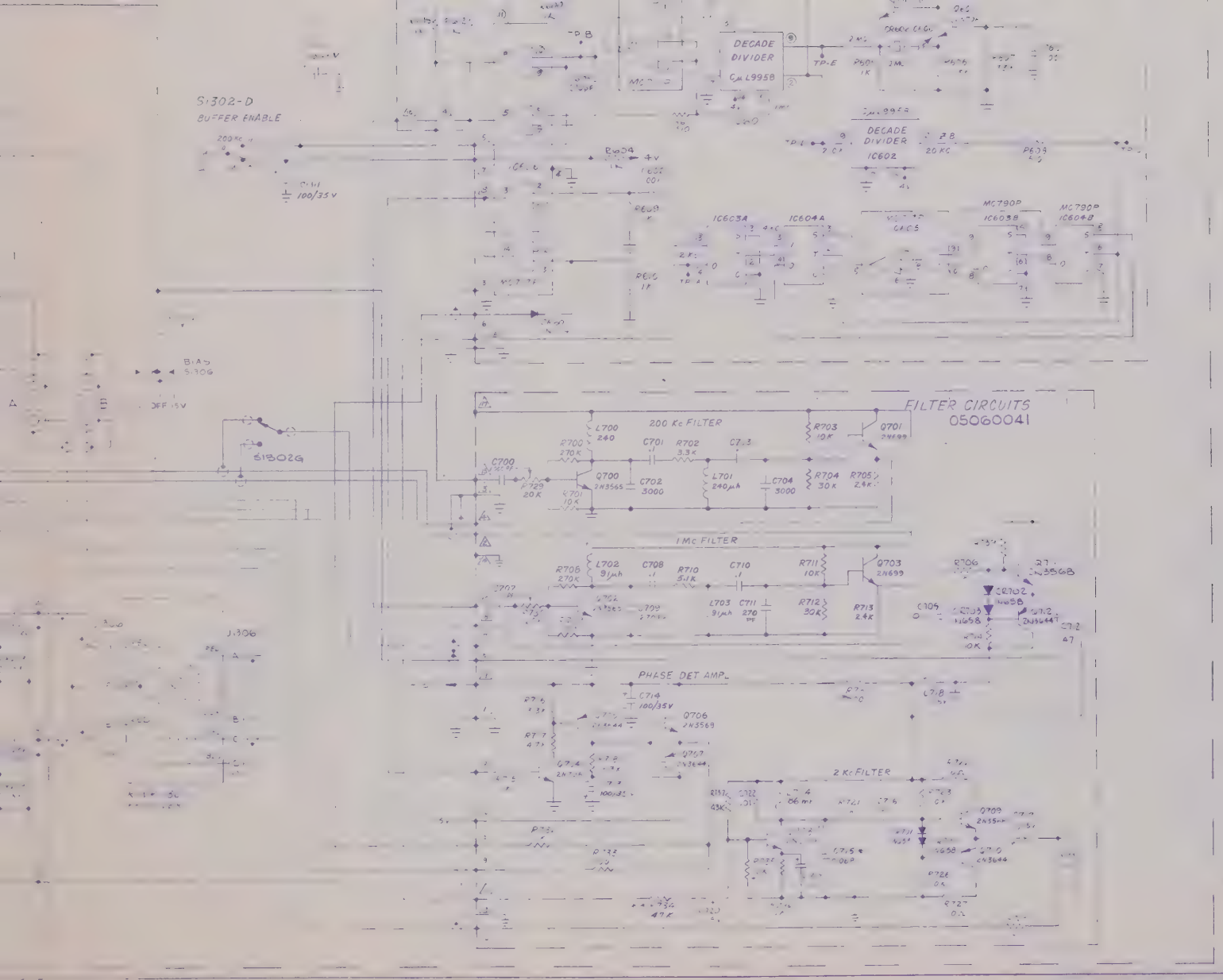


Figure 5-11. ET-3000E Time Delay
Schematic Diagram

SECTION VII

ILLUSTRATED PARTS BREAKDOWN

Figures 7-2 through 7-10 detail all electrical parts of the ET-300E Indicator Unit. The chassis layout is given in Figure 7-1, followed by a detailed parts listing which includes appropriate figure references for the circuit board component breakdowns. A parts listing of the Detector Unit preamplifier circuit board and modulator is contained on page 7-23, 7-24, and 7-25.

The omission of a manufacturer in the parts listing indicates a Rantec or MIL-Spec component.

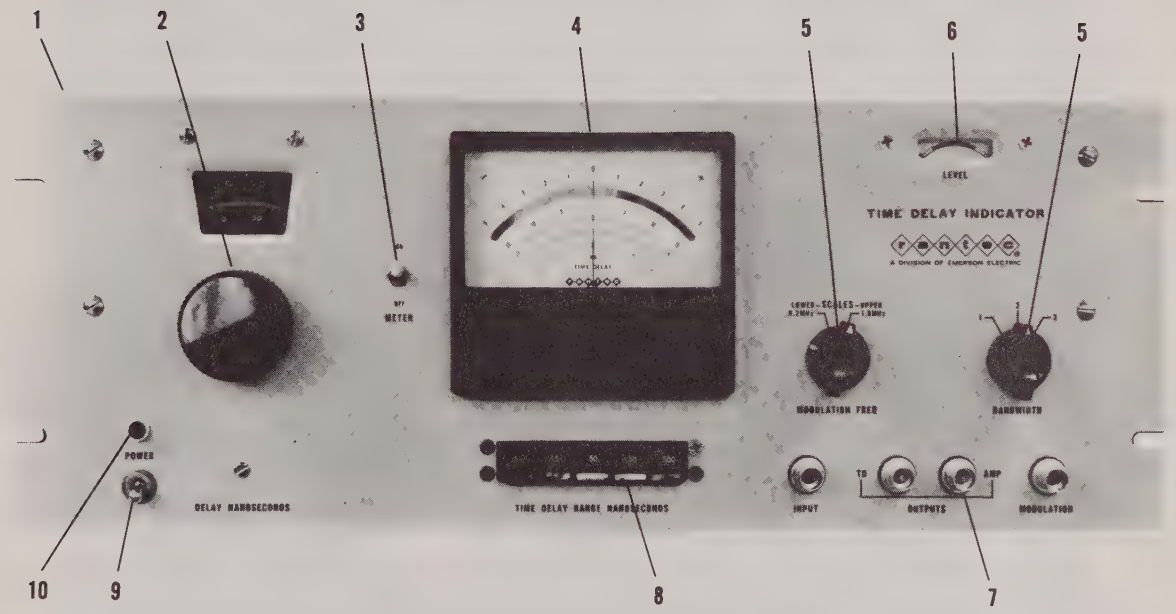


Figure 7-1. ET-300 Time Delay Indicator, Front Panel
(Sheet 1 of 3)

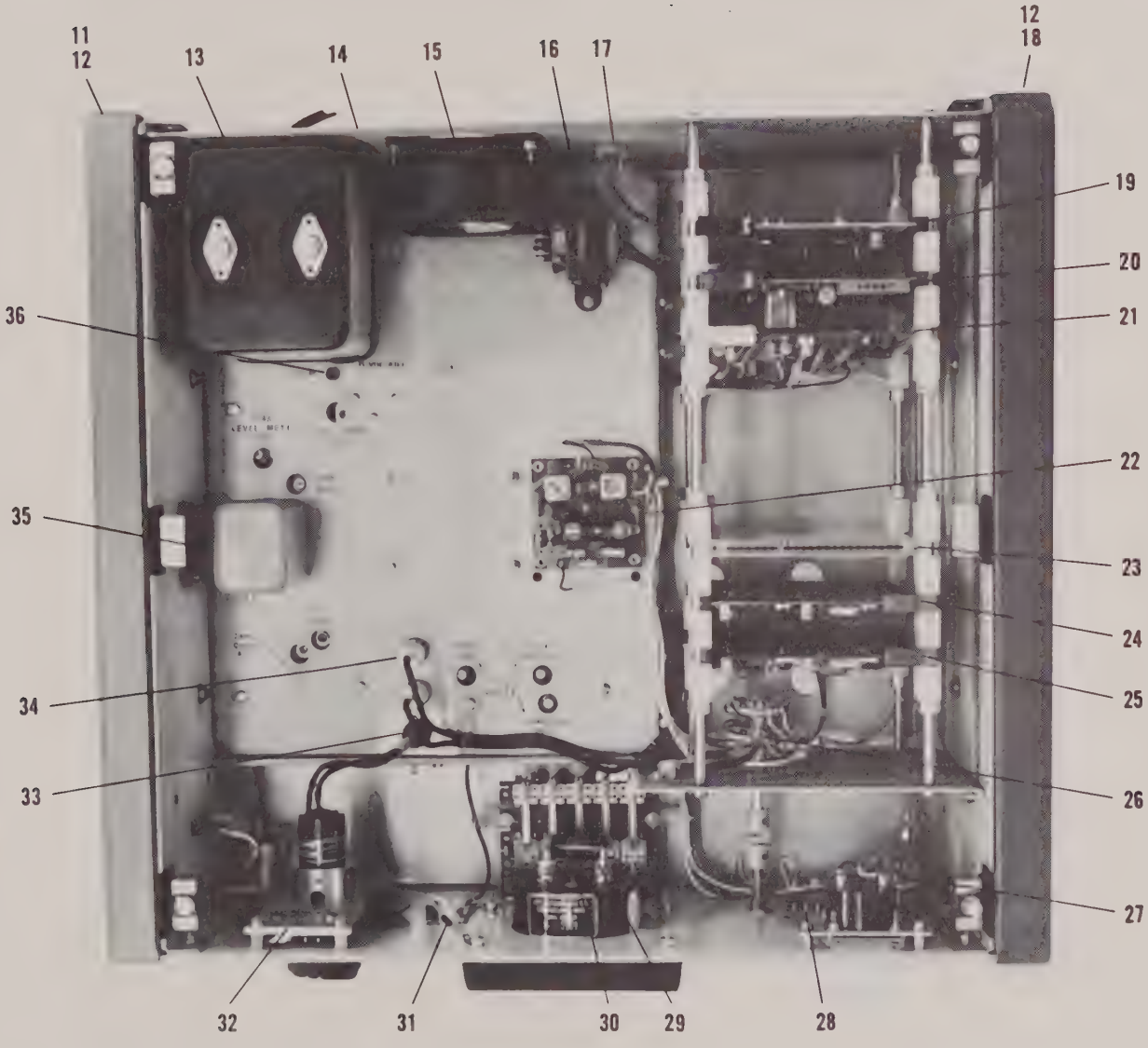


Figure 7-1. ET-300 Time Delay Indicator, Top View
(Sheet 2 of 3)

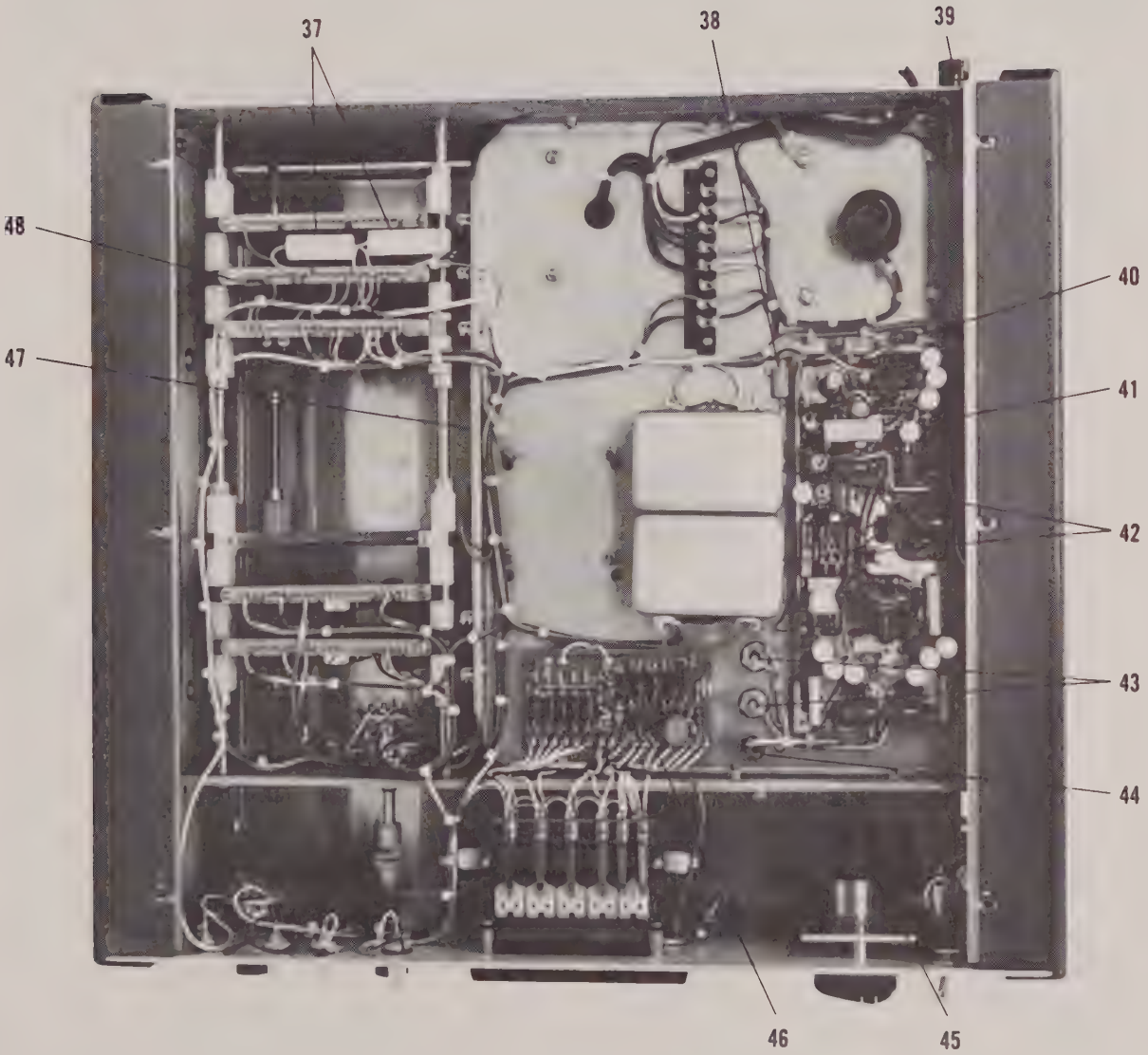


Figure 7-1. ET-300 Time Delay Indicator, Bottom View
(Sheet 3 of 3)

Figure & Index No.	Description	Manufacturer	Part No.	Qty	Reference Designation
7-1	TIME DELAY INDICATOR - ET-300			1	
-1	PANEL, FRONT		100250-1	1	
-2	KNOB, RESOLVER (PART OF DRIVE ASSY)		(REF ITEM 32)	1	
-3	SWITCH, TOGGLE	ALCO	MST-115D	1	S1305
-4	TIME DELAY METER		SP-1088-3	1	M1302
-5	KNOB, SWITCH	H-PACKARD	0370-0112	2	
-6	LEVEL METER	MONARCH	PMC-1S	1	M1301
-7	CONNECTOR, BNC		UG-657/U	4	J1301, J1303, J1304, J1305
-8	SWITCH, PUSHBUTTON		SP-1087-6	1	S1304
-9	SWITCH, TOGGLE	CUTLER-HAMMER	8280K16	1	S1301
-10	INDICATOR	INDUSTRIAL DEVICES	2110A1	1	DS1301
-11	CHASSIS, LEFT SIDE		05511088	1	
-12	END TRIM		SP2112-	2	
-13	POWER SUPPLY	ACOPIAN	15D40D-15D40D	1	PS1301
-14	PANEL, REAR, CHASSIS		05511091	1	
-15	BLOWER	ROTRON	SP2A2	1	
-16	TRANSFORMER	TRIAD	F-14X	1	T500
-17	SWITCH	ALCO	MS-22	1	S1306
-18	CHASSIS, RIGHT SIDE		05511089	1	
-19	POWER SUPPLY ASSY PCB (SEE FIG 7-6 FOR BREAKDOWN)		05060018	1	
-20	FREQUENCY GENERATOR PCB (SEE FIG 7-7 FOR BREAKDOWN)		05060024	1	
-21	FILTER CIRCUIT PCB (SEE FIG 7-8 FOR BREAKDOWN)		05060025	1	
-22	BALANCED MODULATOR, 1 MHz & 200 kHz PCB (SEE FIG 7-2 FOR BREAKDOWN)		05060038	1	
-23	EXTENDER CARD, PCB		05060047	1	
-24	200 kHZ CONVERTER PCB (SEE FIG 7-5 FOR BREAKDOWN)		05060023	1	
-25	1 MHz CONVERTER PCB (SEE FIG 7-4 FOR BREAKDOWN)		05060022	1	
-26	SWITCH, ROTARY	CENTRALAB	PA-2021	1	S1302
-27	SWITCH, ROTARY	CENTRALAB	PA-2015	1	S1303
-28	BANDWIDTH SWITCH ASSY (SEE FIG 7-10 FOR BREAKDOWN)		05511104	1	
-29	CAPACITOR, 10 MFD, 150V	CORNELL-DUBILIER	BBR10-150	1	C1300
-30	SEMICONDUCTOR DEVICE	OHMITE	OMC 7111	1	CR1301
-31	RESISTOR, FIXED, 1K, 5%, 1/4W		RC07GF102J	1	R1301
-32	RESOLVER ASSY		05511109	1	
	RESOLVER	KEARFOTT	R4-235-3A	1	
	DIAL		SP-1091	1	
	RESOLVER DRIVE	RAYTHEON	MV 175-2A-2	1	
-33	CONNECTOR	AMPHENOL	126-195	1	
-34	CONNECTOR, BNC			2	
-35	FILTER		05511045	1	FL1303
-36	TIP JACK (RED)	E. F. JOHNSON	105-202-200	1	TP1301
-37	CAPACITOR, 100 MFD, 35 WVDC	MALLORY	MTA100E1S	2	C1310, C1311
-38	RESISTOR, FIXED, 300, 5W 3/0	DALE	RH-5	1	R229
-39	FUSE	LITTLEFUSE	1/4 AMP SLO-BLO	1	F1301

Figure & Index No	Description	Manufacturer	Part No.	Qty	Reference Designation
7-1					
-40	CAPACITOR, .01 MFD, 400 WVDC, 10%	SPRAGUE	4PS-S10	1	C1309
-41	ZCD CIRCUIT CARD (SEE FIG 7-3 FOR BREAKDOWN)		05060026	1	
-42	FILTER		05511043	2	FL1301, FL1302
-43	CONNECTOR, BNC		UG-625B/U	2	
-44	CONNECTOR	AMPHENOL	126-198	1	
-45	CHASSIS, CROSSPANEL, FRONT		05511090	1	
-46	METER & SWITCH CKT BOARD (SEE FIG 7-9 FOR BREAKDOWN)		05060015	1	
-47	CHASSIS, COMPONENT PLATE		05511086	1	
-48	RESISTOR, FIXED, 1K, 1/4W, 5%		RC07GF102	1	R1302

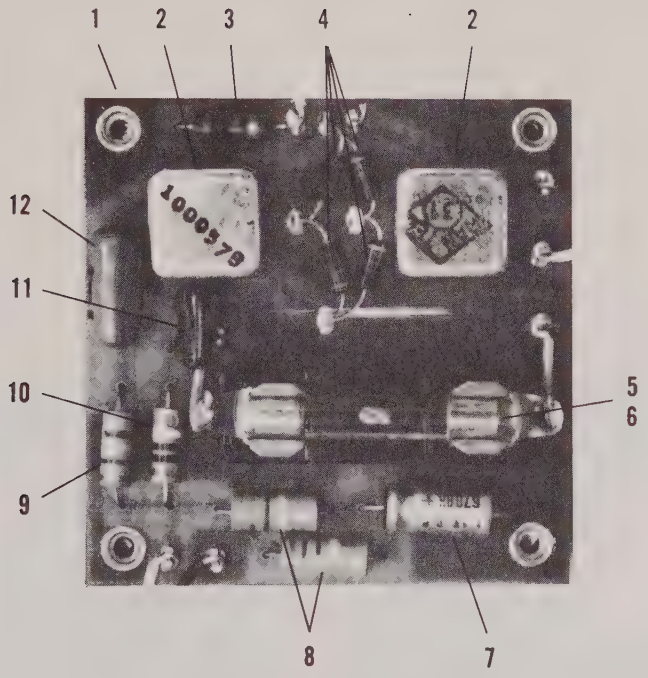
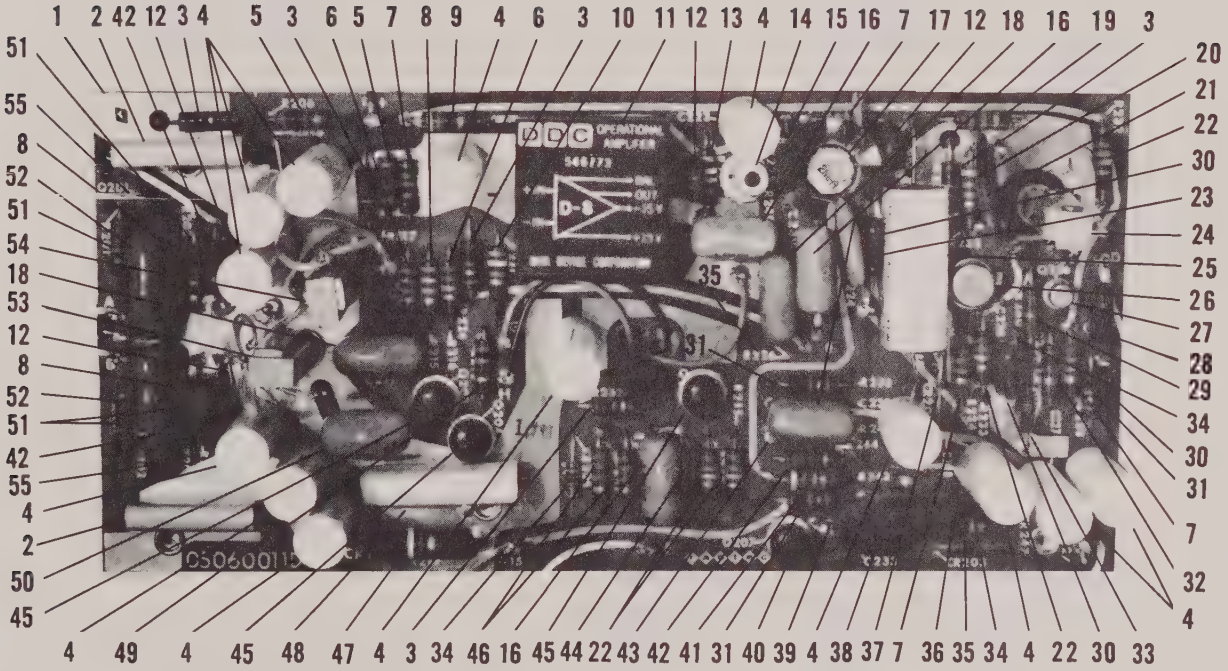


Figure 7-2. 1-MHz and 200-kHz Balanced Modulator

Figure & Index No.	Description	Manufacturer	Part No.	Qty	Reference Designation
7-2	BALANCED MODULATOR, 1 MHz & 200 kHz		05060038	1	
-1	CIRCUIT CARD		05060013	1	
-2	TRANSFORMER	D.B. PRODUCTS	100057B T-TYPE	2	T100, T101
-3	RESISTOR, FIXED, 100Ω, 5%, 1/4W		RC07GF101J	1	R100
-4	SEMICONDUCTOR DEVICE		1N457	4	CR100 thru CR103
-5	HOLDER, FUSE	LITTLE-FUSE	357001	1	XF100
-6	FUSE	LITTLE-FUSE	0.10 AMP	1	F100
-7	CAPACITOR, 1 MFD, 15 WVDC	SPRAGUE	TE1148	1	C101
-8	INDUCTOR, 910 μH	DELEVAN	2500-26	2	L100, L101
-9	INDUCTOR, 240 μH	DELEVAN	1537-94	1	L103
-10	INDUCTOR, 91 μH	DELEVAN	1537-74	1	L102
-11	CAPACITOR, 270 PF	ARCO	DM15-271J	1	C102
-12	CAPACITOR, .0025 MFD	SPRAGUE	6PS-D25	1	C103



NOTE: ITEMS 56 AND 57 MOUNTED ON FAR SIDE.

Figure 7-3. ZCD Circuit

Figure & Index No.	Description	Manufacturer	Part No.	Qty	Reference Designation
7-3	ZCD CIRCUIT PCB		05060026	1	
-1	CIRCUIT CARD		05060011	1	
-2	CAPACITOR, 1 MFD, 1%, 50/100 WVDC		SP-1910-8	2	C202, C207
-3	RESISTOR, FIXED, 1K, 5%, 1/4W		RC07GF102J	5	R205, R211, R224, R236, R252
-4	CAPACITOR, 80 MFD, 30 WVDC	MALLORY	20-46148 (MTV80CK30)	13	C203, C204, C204B, C208, C209, C209B, C219, C219B, C223, C227, C227B, C228, C228B
-5	RESISTOR, FIXED, 100Ω, 5%, 1/4W		RC07GF101J	2	R206, R217
-6	RESISTOR, FIXED, 22K, 5%, 1/4W		RC07GF223J	2	R214, R216
-7	RESISTOR, FIXED, 220Ω, 5%, 1/4W		RC07GF221J	4	R227, R228, R234, R238
-8	RESISTOR, FIXED, 33K, 5%, 1/4W		RC07GF333J	3	R202, R208, R215
-9	RESISTOR, FIXED, 47Ω, 5%, 1/4W		RC07GF470J	1	R220
-10	RESISTOR, FIXED, 390Ω, 5%, 1/4W		RC07GF391J	1	R221
-11	OPERATIONAL AMPLIFIER	DATA DEVICES	MODEL D-8	1	OA201
-12	CAPACITOR, 100PF, 5%	ARCO	DM-15-101J	4	C234, C242, C243, C244
-13	RESISTOR, FIXED, 390K, 5%, 1/4W		RC07GF394J	1	R223
-14	RESISTOR, VARIABLE, 50K	BECKMAN	62P50K	1	R249
-15	RESISTOR, FIXED, 47K, 5%, 1/4W		RC07GF473J	1	R225
-16	CAPACITOR, 0.1 MFD	SPRAGUE	225P10491	4	C221, C222, C232, C240
-17	TRANSISTOR		2N699	1	Q205
-18	CAPACITOR, 0.01 MFD, 10%, 400 WVDC	SPRAGUE	4PS-S10	2	C211, C239
-19	RESISTOR, FIXED, 510Ω, 5%, 1/4W		RC07GF511J	1	R231
-20	RESISTOR, FIXED, 470Ω, 5%, 1/4W		RC07GF471J	1	R235
-21	CAPACITOR, 0.22 MFD, +80% -20%, 25WVDC	ERIE	5865-000-Y5U-224Z	1	C226
-22	RESISTOR, FIXED, 51K, 5%, 1/4W		RC07GF513J	4	R232, R233, R250, R255
-23	CAPACITOR, 0.1 MFD	SPRAGUE	TG-P10	1	C224
-24	RESISTOR, VARIABLE, 100K	BECKMAN	78P-100K	1	R237
-25	CAPACITOR, 5 MFD, 1%		SP-1910-9	1	C225
-26	OPERATIONAL AMPLIFIER	FAIRCHILD	UA-710C	1	OA202
-27	TRANSISTOR		2N706	1	Q206
-28	CAPACITOR, 330 PF	ARCO	DM-15-331J	1	C231
-29	RESISTOR, FIXED, 5.1K, 5%, 1/4W		RC07GF512J	1	R240
-30	CAPACITOR, 1000 PF, 5%, 100 WVDC	ARCO	DM-15-102J	3	C235, C236, C241
-31	RESISTOR, FIXED, 10K, 5%, 1/4W		RC07GF103J	3	R230, R241, R245
-32	RESISTOR, FIXED, 2K, 5%, 1/4W		RC07GF202J	1	R239
-33	SEMICONDUCTOR DEVICE		1N5242	1	CR201
-34	SEMICONDUCTOR DEVICE		1N100	3	CR203, CR205, CR206
-35	RESISTOR, FIXED, 20K, 5%, 1/4W		RC07GF203J	2	R226, R247
-36	SEMICONDUCTOR DEVICE	TEXAS INST.	G-129	1	CR204
-37	SEMICONDUCTOR DEVICE		1N5233	1	CR202
-38	CAPACITOR, 0.47 MFD, +80% -20%, 25 WVDC	ERIE	5865-000-Y5U-472Z	1	C233
-39	RESISTOR, FIXED, 68Ω, 5%, 1/4W		RC07GF680J	1	R246
-40	TRANSISTOR		2N3566	1	Q207
-41	RESISTOR, FIXED, 91K, 5%, 1/4W		RC07GF913J	1	R243
-42	RESISTOR, FIXED, 2.2K, 5%, 1/4W		RC07GF222J	3	R204, R210, R244
-43	RESISTOR, FIXED, 68K, 5%, 1/4W		RC07GF683J	1	R242
-44	RESISTOR, FIXED, 2.7K, 5%, 1/4W		RC07GF272J	1	R251

Figure & Index No.	Description	Manufacturer	Part No.	Qty	Reference Designation
7-3					
-45	TRANSISTOR		2N3568	3	Q203, Q204, Q208
-46	RESISTOR, FIXED, 510Ω, 5%, 1/4W		RC07GF511J	2	R253, 254
-47	RESISTOR, FIXED, 390Ω, 5%, 1W		RC32GF391J	1	R219
-48	CAPACITOR, 2 MFD, 1%		SP-1910-7	1	C213
-49	RESISTOR, FIXED, 51Ω, 5%, 1/4W		RC07GF510J	1	R218
-50	CAPACITOR, .005 MFD	SPRAGUE	6PS-D50	1	C210
-51	RESISTOR, FIXED, 15K, 5%, 1/4W		RC07GF153J	4	R201, R203, R207, R209
-52	CAPACITOR, .02 MFD	SPRAGUE	2PS-S20	2	C201, C206
-53	RESISTOR, VARIABLE, 10K	BECKMAN	78P-10K	1	R212
-54	RESISTOR, VARIABLE, 50K	BECKMAN	78P-50K	1	R213
-55	TRANSISTOR		2N3565	2	Q201, Q202
-56	RESISTOR, VARIABLE, 10K	BECKMAN	62P10K	1	R248
-57	RESISTOR, VARIABLE, 100K	BECKMAN	62P100K	1	R222

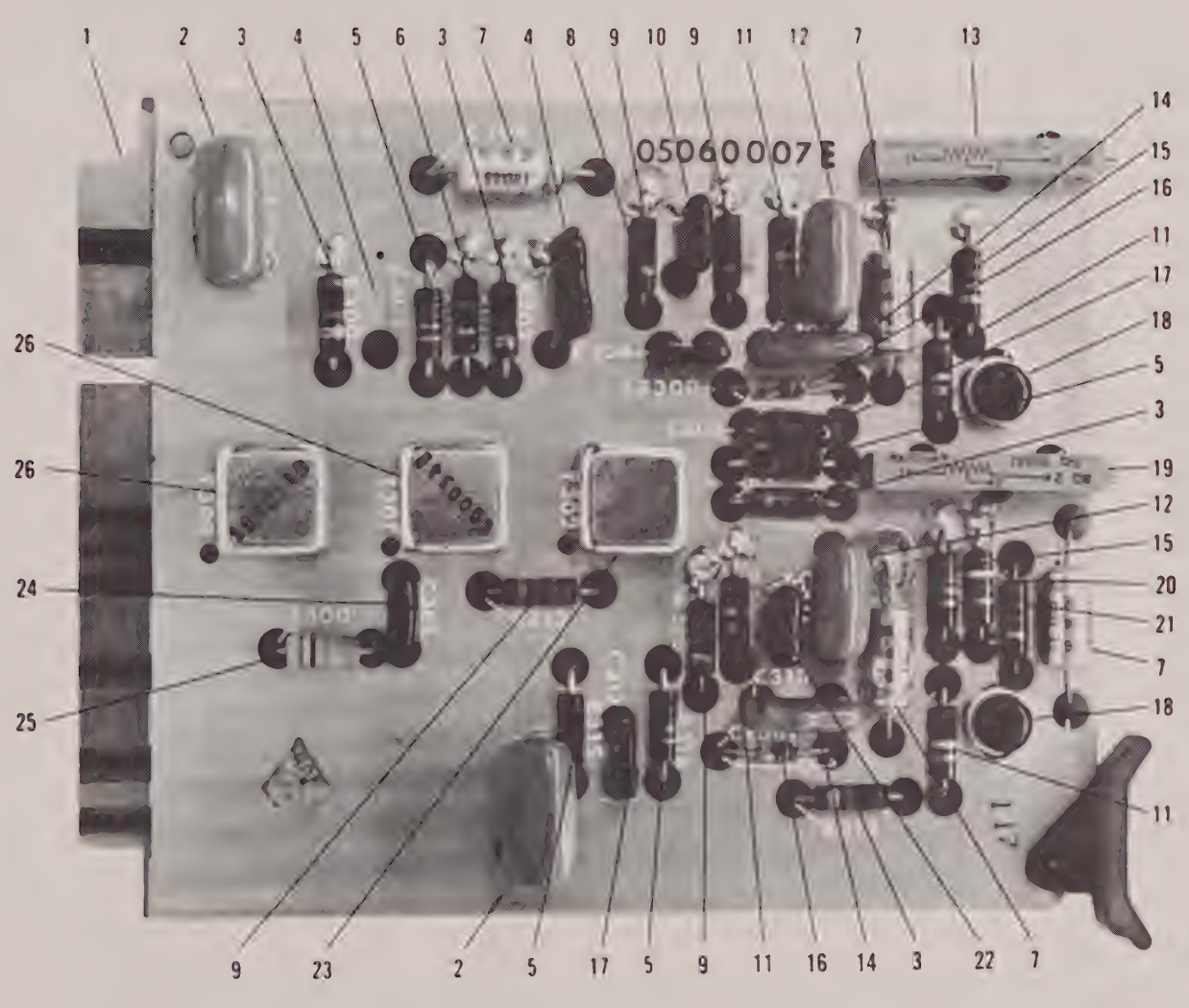


Figure 7-4. 1-MHz Converter

Figure & Index No.	Description	Manufacturer	Part No.	Qty	Reference Designation
7-4	1 MHz CONVERTER PCB		05060022	1	
-1	CIRCUIT CARD		05060007	1	
-2	CAPACITOR, .047 MFD, 10%, 200 WVDC	SPRAGUE	2PS-S47	2	C315, C316
-3	RESISTOR, FIXED, 100Ω, 5%, 1/4W		RC07GF101J	4	R300, R302, R306, R314
-4	CAPACITOR		SELECT AT TEST	A/R	C302A, C302B
-5	RESISTOR, FIXED, 5.1K, 5%, 1/4W		RC07GF512J	4	R303, R305, R315, R316
-6	RESISTOR, FIXED, 51Ω, 5%, 1/4W		RC07GF510J	1	R301
-7	CAPACITOR 10/15V	SPRAGUE	TE-1155	4	C308, C309, C313, C314
-8	CAPACITOR, 330 PF, 5%, 500 WVDC	ARCO	DM-15-331J	1	C304
-9	RESISTOR, FIXED, 510Ω, 5%, 1/4W		RC07GF511J	4	R304, R309, R312, R313
-10	CAPACITOR, 200 PF, 5%, 500 WVDC	ARCO	DM-15-201J	1	C303
-11	RESISTOR, FIXED, 100K, 5%, 1/4W		RC07GF104J	4	R307, R308, R317, R318
-12	CAPACITOR, .002 MFD, 10%, 600 WVDC	SPRAGUE	6PS-D20	2	C307, C312
-13	RESISTOR, VARIABLE, 500Ω	BECKMAN	78PR500	1	R311
-14	CAPACITOR, .015 MFD, 10%, 100 WVDC	SPRAGUE	225PW	2	C306, C310
-15	RESISTOR, FIXED, 51K, 5%, 1/4W		RC07GF513J	2	R310, R320
-16	SEMICONDUCTOR DEVICE		1N100	2	CR300, CR301
-17	CAPACITOR, 250 PF, 5%, 500 WVDC	ARCO	DM-15-251J	2	C305, C317
-18	TRANSISTOR		2N3568	2	Q300, Q301
-19	RESISTOR, VARIABLE, 50K	BECKMAN	78PR50K	1	R319
-20	RESISTOR, FIXED, 390Ω, 5%, 1/4W		RC07GF391J	1	R322
-21	RESISTOR, FIXED, 150Ω, 5%, 1/4W		RC07GF151J	1	R321
-22	CAPACITOR, 1000 PF, 5%, 100 WVDC	ARCO	DM-15-102J	1	C311
-23	TRANSFORMER	D.B. PRODUCTS	100057 T-TYPE	1	T302
-24	CAPACITOR, 680 PF, 5%	ARCO	DM-15-681J	1	C301
-25	INDUCTOR, 47 μH	DELEVAN	1537-60	1	L300
-26	TRANSFORMER	D.B. PRODUCTS	100054 T-TYPE	2	T300, T301

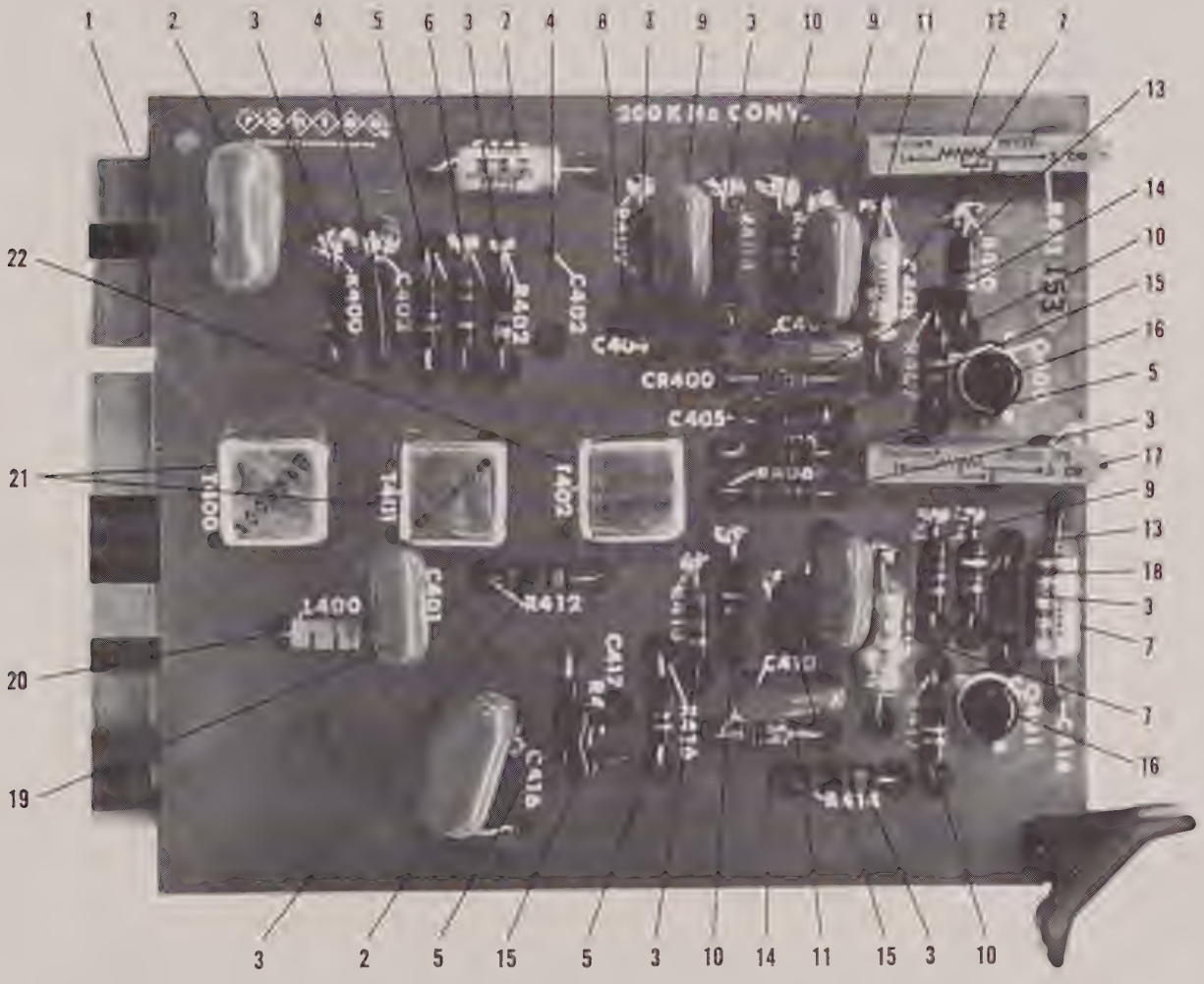


Figure 7-5. 200-kHz Converter

Figure & Index No.	Description	Manufacturer	Part No.	Qty	Reference Designation
7-5	200 kHz CONVERTER CARD		05060023	1	
-1	CIRCUIT CARD		05060007	1	
-2	CAPACITOR, .047 MFD, 10%, 200 WVDC	SPRAGUE	2PS-S47	2	C415, C416
-3	RESISTOR, FIXED, 100Ω, 5%, 1/4W		RC07GF101J	9	R400, R402, R406, R409, R412, R413, R414, R421, R404
-4	CAPACITOR	SPRAGUE	SELECT AT TEST	A/R	C402A, C402B
-5	RESISTOR, FIXED, 5.1K, 5%, 1/4W		RC07GF512J	4	R403, R405, R415, R416
-6	RESISTOR, FIXED, 51Ω, 5%, 1/4W		RC07GF510J	1	R401
-7	CAPACITOR, 10/15V	SPRAGUE	TE-1155	4	C408, C409, C413, C414
-8	CAPACITOR, 7500 PF, 5%	CORNELL-DUBILIER	CD30F752J	1	C404
-9	CAPACITOR, .002 MFD, 10%, 600 WVDC	SPRAGUE	6PS-D20	3	C403, C407, C412
-10	RESISTOR, FIXED, 100K, 5%, 1/4W		RC07GF104J	4	R407, R408, R417, R418
-11	CAPACITOR, .015 MFD, 10%, 100 WVDC	SPRAGUE	225 PW	2	C406, C410
-12	RESISTOR, VARIABLE, 500Ω	BECKMAN	78PR500	1	R411
-13	RESISTOR, FIXED, 51K, 5%, 1/4W		RC07GF513J	2	R410, R420
-14	SEMICONDUCTOR DEVICE		1N100	2	CR400, CR401
-15	CAPACITOR, 1000 PF, 5%, 100 WVDC	ARCO	DM-15-102J	3	C405, C411, C417
-16	TRANSISTOR		2N3568	2	Q400, Q401
-17	RESISTOR, VARIABLE, 50K	BECKMAN	78PR50K	1	R419
-18	RESISTOR, FIXED, 390Ω, 5%, 1/4W		RC07GF391J	1	R422
-19	CAPACITOR, .0025 MFD, 10%, 600 WVDC	SPRAGUE	6PS-D25	1	C401
-20	INDUCTOR, 240 μH	DELEVAN	1537-94	1	L400
-21	TRANSFORMER	D.B. PRODUCTS	100054 T-TYPE	2	T400, T401
-22	TRANSFORMER	D.B. PRODUCTS	100057 T-TYPE	1	T402

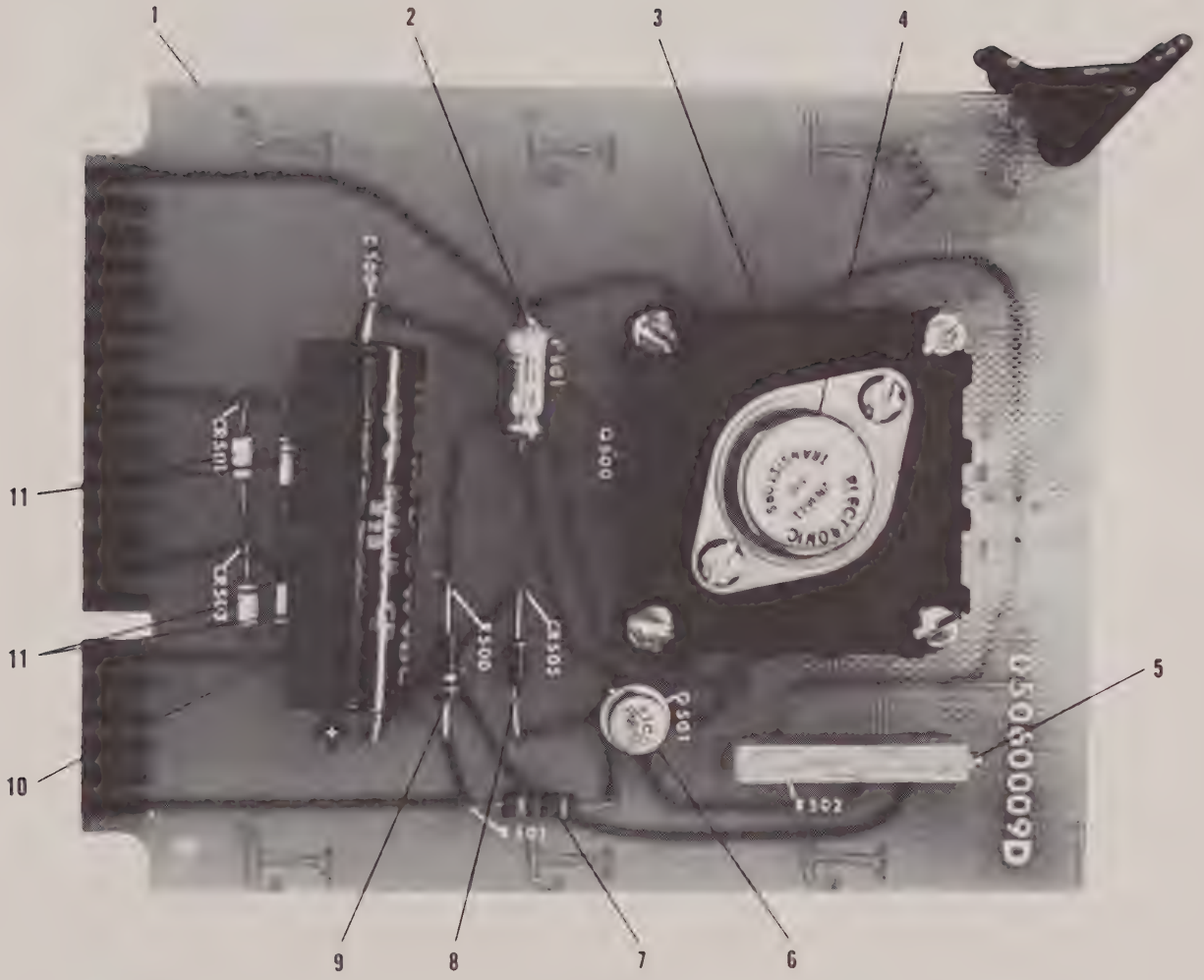


Figure 7-6. Power Supply

Figure & Index No.	Description	Manufacturer	Part No.	Qty	Reference Designation
7-6	POWER SUPPLY ASSY.		05060018	1	
-1	CIRCUIT CARD		05060009	1	
-2	CAPACITOR, 10 MFD, 15 WVDC	SPRAGUE	TE-1155	1	C501
-3	HEAT DISSIPATOR	WAKEFIELD	NC 680-. 5A	1	
-4	TRANSISTOR		2N3611	1	Q500
-5	RESISTOR, VARIABLE, 10K	BECKMAN	78P10K	1	R502
-6	TRANSISTOR		2N652	1	Q501
-7	RESISTOR, FIXED, 820Ω, 5%, 1/4W		RC07GF821J	1	R501
-8	SEMICONDUCTOR DEVICE		1N4370	1	CR505
-9	RESISTOR, FIXED, 1K, 5%, 1/4W		RC07GF102J	1	R500
-10	CAPACITOR, 1000 MFD, 15 WVDC	CORNELL-DUBILIER	BR1000-6	1	C500
-11	SEMICONDUCTOR DEVICE	DIODES INC.	TS2	4	CR501, CR502, CR503, CR504

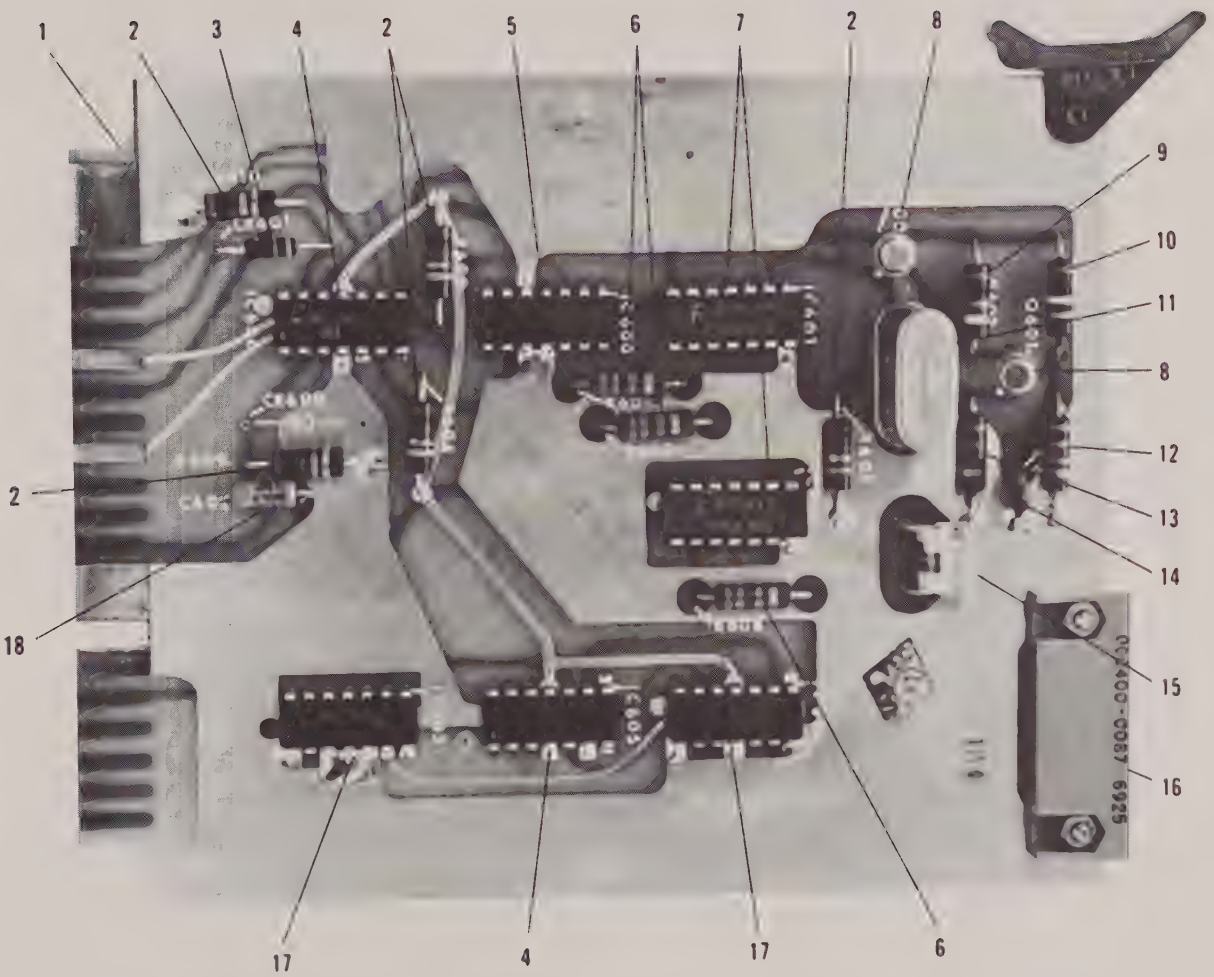


Figure 7-7. Frequency Generator

Figure & Index No.	Description	Manufacturer	Part No.	Qty	Reference Designation
7-7	FREQUENCY GENERATOR ASSY.		05060024	1	
-1	CIRCUIT CARD		05060003	1	
-2	RESISTOR, FIXED, 1K, 5%, 1/4W		RC07GF102J	5	R600, R604, R605, R609, R610
-3	SEMICONDUCTOR DEVICE		1N914	1	CR601
-4	INTEGRATED CIRCUIT	MOTOROLA	MC717P	2	IC605, IC606
-5	INTEGRATED CIRCUIT	MOTOROLA	MC723P	1	IC600
-6	RESISTOR, FIXED, 510Ω, 5%, 1/4W		RC07GF511J	3	R601, R608, R611
-7	INTEGRATED CIRCUIT (U5B995879 ALTERNATE)	FAIRCHILD	U6A995879	2	IC601, IC602
-8	TRANSISTOR		2N706	2	Q600, Q601
-9	RESISTOR, FIXED, 10K, 5%, 1/4W		RC07GF103J	1	R602
-10	RESISTOR, FIXED, 120K, 5%, 1/4W		RC07GF124J	1	R603
-11	CRYSTAL OSCILLATOR, 2 MHz	TEXAS INSTRUMENTS	HC-6	1	CR602
-12	RESISTOR, FIXED, 33K, 5%, 1/4W		RC07GF333J	1	R607
-13	RESISTOR, FIXED, 1.5K, 5%, 1/4W		RC07GF152J	1	R606
-14	CAPACITOR, .001 MFD	ERIE	CK60AW102M	1	C601
-15	CAPACITOR, VARIABLE 5.5 - 19 PF	ERIE	538-006-COPO-92R	1	C600
-16	TEST JACK, MULTIPLE	VIKING	000400-0087-692P	1	TP1 thru TP5 (A - E)
-17	INTEGRATED CIRCUIT	MOTOROLA	MC790P	2	IC603, IC604
-18	CAPACITOR, .001 MFD, 10%, 200 WVDC	SPRAGUE	192P10292	1	C602

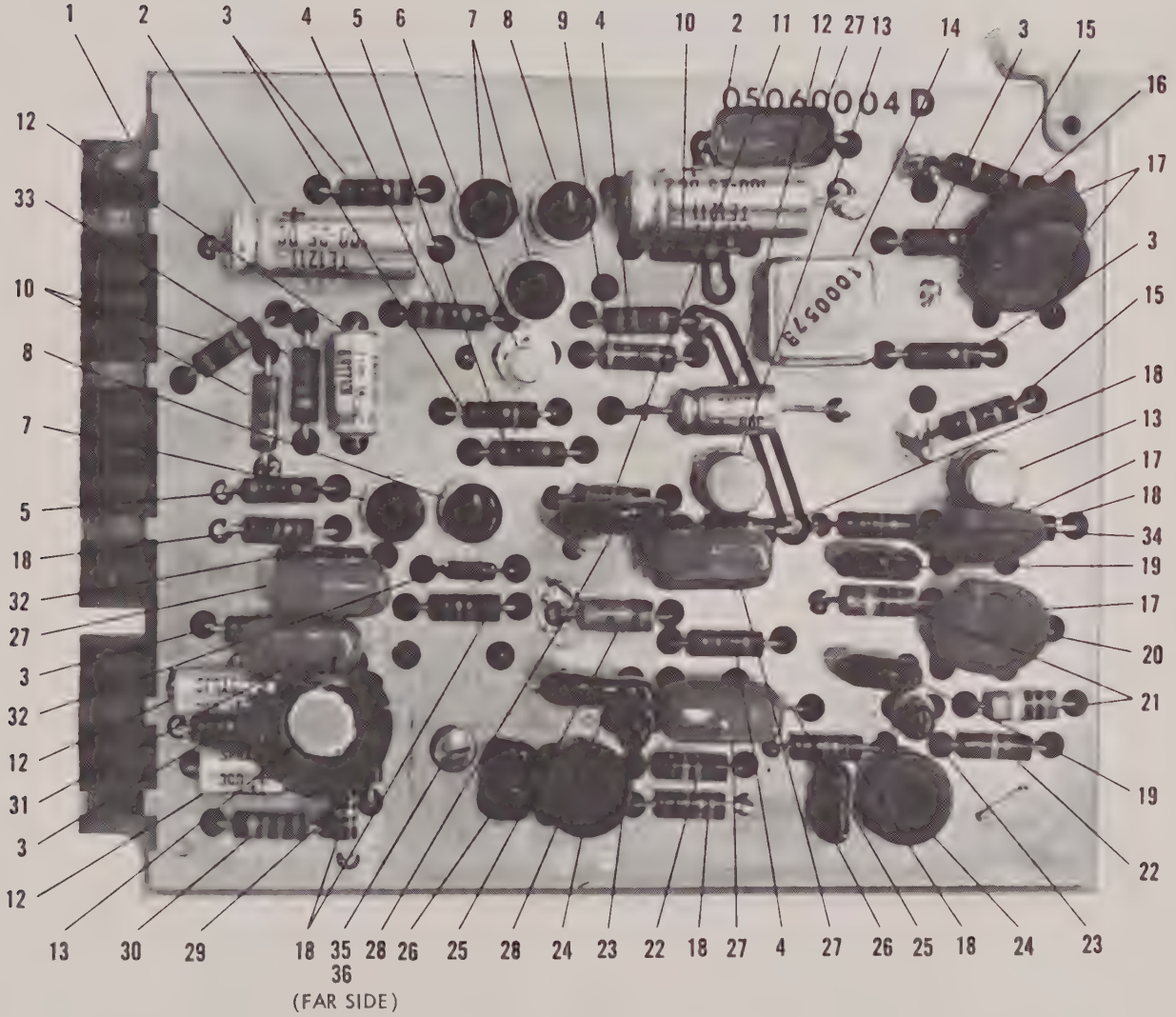


Figure 7-8. Filter Circuit

Figure & Index No.	Description	Manufacturer	Part No.	Qty	Reference Designation
7-8	FILTER CIRCUIT ASSY.		05060025	1	
-1	CIRCUIT CARD		05060004	1	
-2	CAPACITOR, 100/35V	MALLORY	MTA100F35	2	C713, C714
-3	RESISTOR, FIXED, 1K, 5%, 1/4W		RC07GF102J	6	R706, R714, R715, R721, R732, R736
-4	RESISTOR, FIXED, 3.3K, 5%, 1/4W		RC07GF332J	3	R702, R716, R718
-5	RESISTOR, FIXED, 10Ω, 5%, 1/4W		RC07GF100J	2	R722, R727
-6	TRANSISTOR		2N706	1	Q704
-7	TRANSISTOR		2N3644	3	Q705, Q707, Q710
-8	TRANSISTOR		2N3568	2	Q706, Q709
-9	RESISTOR, FIXED, 4.7K, 5%, 1/4W		RC07GF472J	1	R717
-10	RESISTOR, FIXED, 100Ω, 5%, 1/4W		RC07GF101J	3	R731, R733, R738
-11	RESISTOR, FIXED, 30K, 5%, 1/4W		RC07GF303J	1	R704
-12	CAPACITOR, 1/15V	SPRAGUE	TE-1148	4	C717 thru C720
-13	TRANSISTOR		2N699	3	Q701, Q703 Q708
-14	TRANSFORMER	D. B. PRODUCTS	100057 T-TYPE	1	T700
-15	RESISTOR, FIXED, 2.4K, 5%, 1/4W		RC07GF242J	2	R705, R713
-16	CAPACITOR, 100 PF	ARCO	DM-5-101J	1	C721
-17	CAPACITOR, 0.1 MFD, 100 WVDC	SPRAGUE	TG-P10	4	C705, C708, C710, C712
-18	RESISTOR, FIXED, 10K, 5%, 1/4W		RC07GK103J	7	R701, R703, R709, R711, R723, R726, R735
-19	CAPACITOR, 270 PF, 5%, 500 WVDC	ARCO	DM-15-271J	2	C709, C711
-20	RESISTOR, FIXED, 5.1K, 5%, 1/4W		RC07GF512J	1	R710
-21	INDUCTOR, 91 μH	DELEVAN	1537-74	2	L702, L703
-22	RESISTOR, FIXED, 270K, 5%, 1/4W		RC07GF274J	2	R700, R708
-23	TRANSISTOR		2N3565	1	Q700, Q702
-24	RESISTOR, VARIABLE, 20K	BOURNS	3367-P-1-203	2	R729, R730
-25	INDUCTOR, 240 μH	DELEVAN	1537-94	2	L700, L701
-26	CAPACITOR, 1000 PF, 5%, 100 WVDC	ARCO	DM-15-102J	2	C700, C707
-27	CAPACITOR, 0.1 MFD, 10%, 100 WVDC	SPRAGUE	225P10491	4	C701, C703, C716, C706
-28	CAPACITOR, 3000 PF, 5%	CORNELL-DUBILIER	CD19F302J	2	C702, C704
-29	RESISTOR, FIXED, 43K, 5%, 1/4W		RC07GF433J	1	R737
-30	RESISTOR, FIXED		SELECT AT TEST	1	R734
-31	CAPACITOR, FIXED		SELECT AT TEST	1	C715
-32	SEMICONDUCTOR DEVICE		1N658	2	CR700, CR701
-33	RESISTOR, FIXED, 220Ω, 5%, 1/4W		RC07GF221J	1	R728
-34	RESISTOR, FIXED, 22K, 5%, 1/4W		RC07GF223J	1	R712
-35	CAPACITOR, .01 MFD, 10%, 100 WVDC	ARCO	1DP-1-103	1	C722
-36	INDUCTOR, 86 μH	COLLINS	MPF-050-17B	1	L704

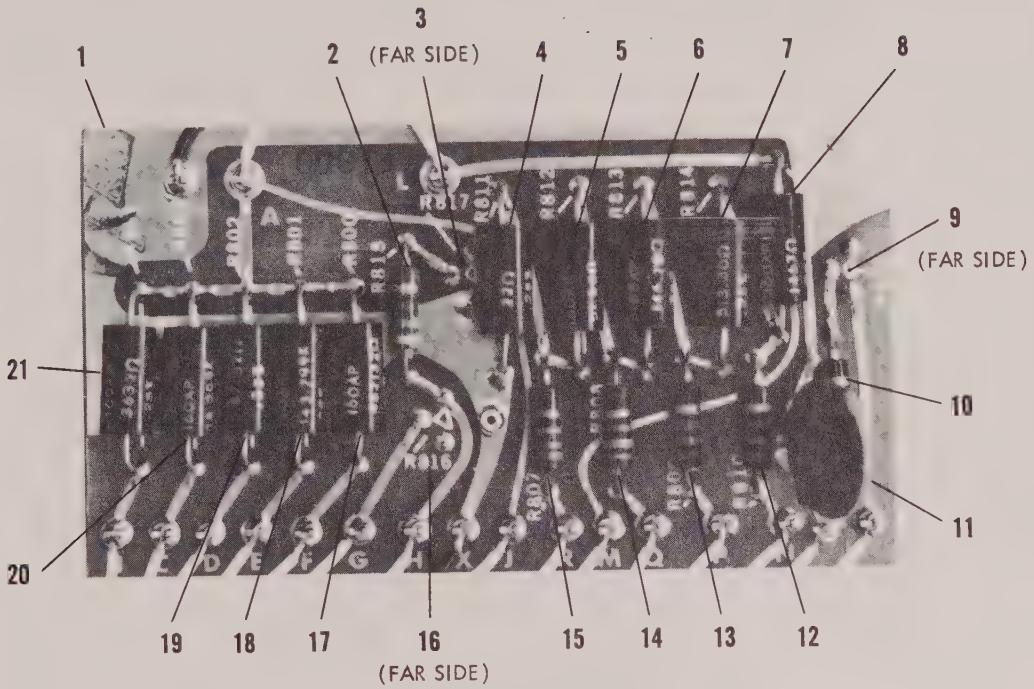


Figure 7-9. Meter and Switch Circuit

Figure & Index No.	Description	Manufacturer	Part No.	Qty	Reference Designation
7-9	METER AND SWITCH PCB		05060015	1	
-1	CIRCUIT CARD		05511008	1	
-2	RESISTOR, FIXED, 4.7K, 1/4W, 5%		RC07GF472J	1	R818
-3	RESISTOR, VARIABLE, 2K	BECKMAN	62P2K	1	R817
-4	RESISTOR, FIXED, 22 Ω , 1/4W, 0.25%		SP-1911-4	1	R811
-5	RESISTOR, FIXED, 51.35Ω, 1/4W, 0.25%		SP-1911-25	1	R812
-6	RESISTOR, FIXED, 146.7Ω, 1/4W, 0.25%		SP-1911-26	1	R813
-7	RESISTOR, FIXED, 513.3Ω, 1/4W, 0.25%		SP-1911-27	1	R814
-8	RESISTOR, FIXED, 1.467K, 1/4W, 0.25%		SP-1911-28	1	R815
-9	RESISTOR, VARIABLE, 10K	BECKMAN	62P10K	1	R805
-10	RESISTOR, FIXED, 1.8K, 1/4W, 5%		RC07GF182J	1	R806
-11	CAPACITOR, 0.1 MFD	SPRAGUE	TG-P10	1	C800
-12	RESISTOR, FIXED, 180Ω, 1/4W, 5%		RC07GF181J	1	R810
-13	RESISTOR, FIXED, 560Ω, 1/4W, 5%		RC07GF561J	1	R809
-14	RESISTOR, FIXED, 680Ω, 1/4W, 5%		RC07GF681J	1	R808
-15	RESISTOR, FIXED, 750Ω, 1/4W, 5%		RC07GF751J	1	R807
-16	RESISTOR, VARIABLE, 500Ω	BECKMAN	62P500	1	R816
-17	RESISTOR, FIXED, 482.132K, 1/4W, 0.25%		SP-1911-24	1	R800
-18	RESISTOR, FIXED, 143.799K, 1/4W, 0.25%		SP-1911-29	1	R801
-19	RESISTOR, FIXED, 47.132K, 1/4W, 0.25%		SP-1911-20	1	R802
-20	RESISTOR, FIXED, 13.299K, 1/4W, 0.25%		SP-1911-30	1	R803
-21	RESISTOR, FIXED, 3.632K, 1/4W, 0.25%		SP-1911-16	1	R804

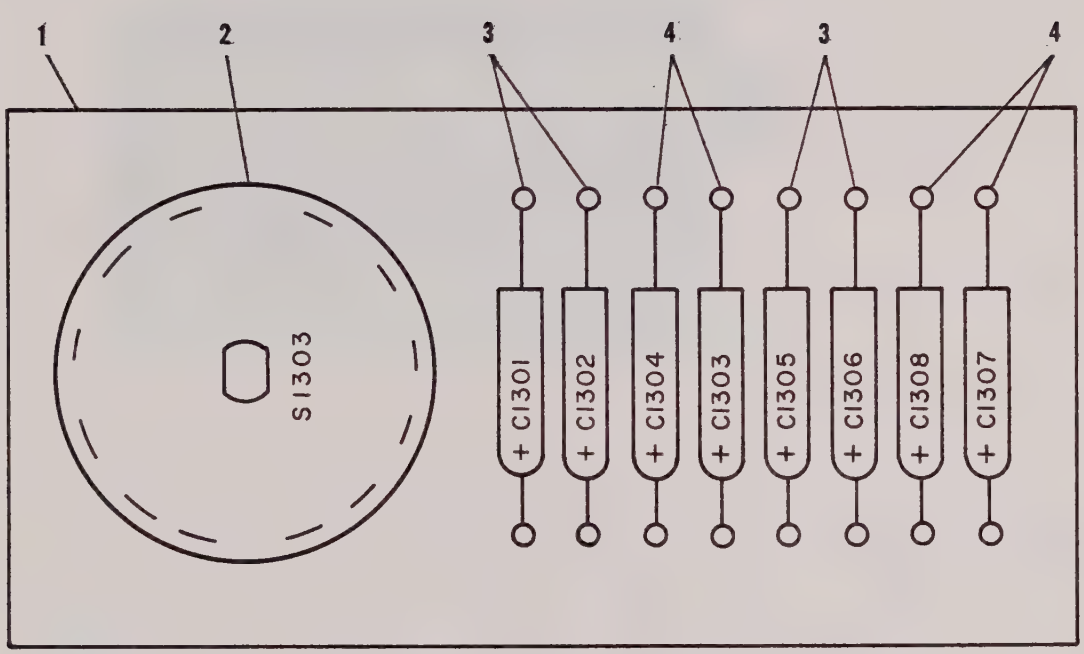


Figure 7-10. Bandwidth Switch Circuit

Figure & Index No.	Description	Manufacturer	Part No.	Qty	Reference Designation
7-10	BANDWIDTH SWITCH WIRING ASSY.		05511104	1	
-1	CIRCUIT CARD		05511104	1	
-2	SWITCH, ROTARY, 3 POS.	CENTRALAB	PA-2015	1	S1303
-3	CAPACITOR, 10 MFD, 20 WVDC	KEMET	K10C20K	4	C1301, C1302, C1305, C1306
-4	CAPACITOR, 22 MFD, 15 WVDC	KEMET	K22C15K	4	C1303, C1304, C1307, C1308

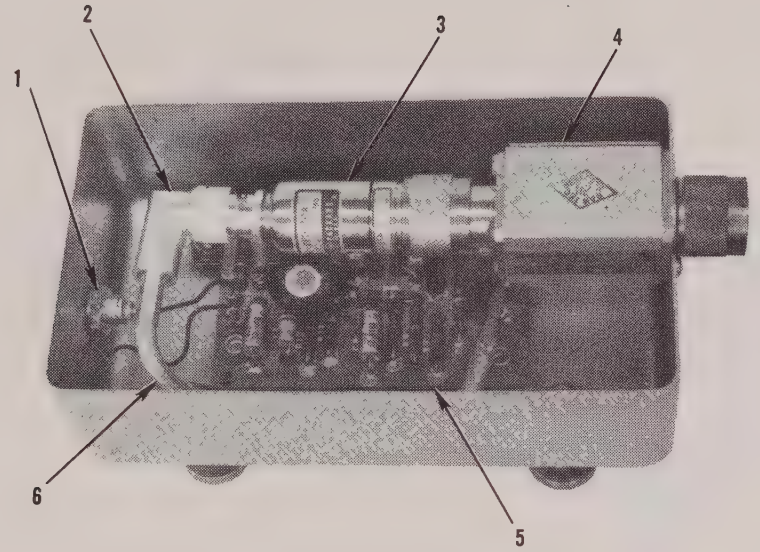


Figure 7-11. Time Delay Detector ET-300D-AB

Figure & Index No.	Description	Manufacturer	Part No.	Qty	Reference Designation
7-11	ET300D-AB DETECTOR			1	
-1	CONNECTOR		UG-657/U	1	
-2	CONNECTOR	AMPHENOL	95575	2	
-3	CRYSTAL DETECTOR	HEWLETT/ PACKARD	423A	1	
-4	PAD		B5103-61	1	
-5	PREAMPLIFIER, DETECTOR		05060014	1	
	CIRCUIT CARD		05060005	1	PC1
	RESISTOR, FIXED, 100Ω, 5%, 1/2W		RC20GF101J	3	R1, R3, R12
	RESISTOR, FIXED, 1K, 5%, 1/2W		RC20GF102J	1	R2
	RESISTOR, FIXED, 100K, 5%, 1/2W		RC20GF104J	1	R4
	RESISTOR, FIXED, 5.1K, 5%, 1/2W		RC20GF512J	2	R5, R10
	RESISTOR, FIXED, 24Ω, 5%, 1/2W		RC20GF240J	1	R6
	RESISTOR, FIXED, 51K, 5%, 1/2W		RC20GF513J	1	R7
	RESISTOR, FIXED, 20K, 5%, 1/2W		RC20GF203J	1	R8
	RESISTOR, FIXED, 18Ω, 5%, 1/2W		RC20GF180J	1	R9
	RESISTOR, FIXED, 1.2K, 5%, 1/2W		RC20GF122J	1	R11
	RESISTOR, FIXED, 47Ω, 5%, 1/2W		RC20GF470J	1	R13
	TRANSISTOR		2N3565	1	Q1
	TRANSISTOR		2N3906	1	Q2
	TRANSISTOR		2N699	1	Q3
	INDUCTOR, 910 μH	DELEVAN	2500-26	2	L1, L2
	CAPACITOR, 10 MFD, 15V	SPRAGUE	TE-1155	2	C1, C2
	CAPACITOR, 1MFD, 15V	SPRAGUE	TE-1148	5	C3, C4, C6, C8, C9
	CAPACITOR, 820 PF	ARCO	DM15-821J	1	C7
	RESISTOR, FIXED, 510K, 5%, 1/4W		RC20GF514J	1	R14
-6	CABLE		RG-55/U	A/R	

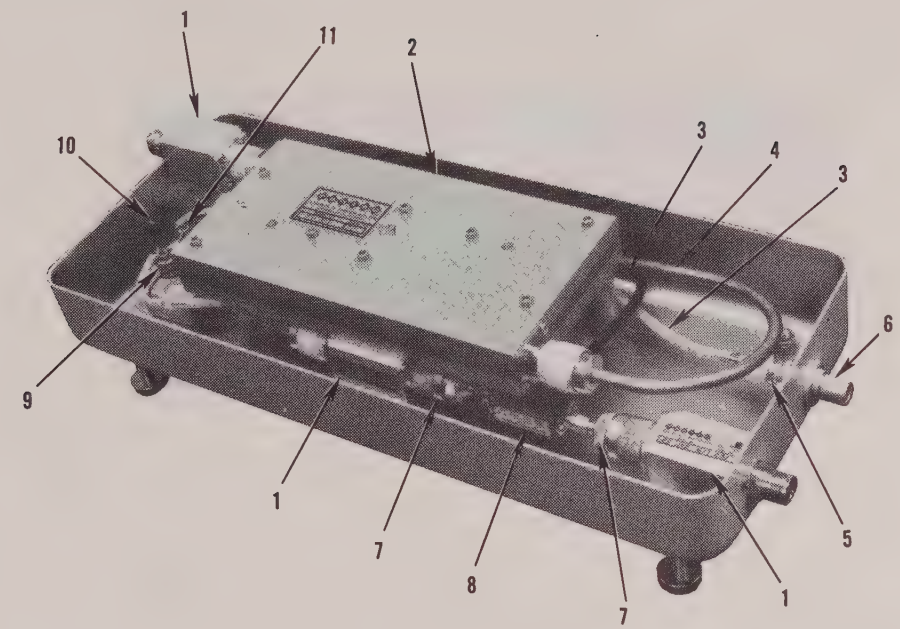


Figure 7-12. Time Delay Modulator ET-300M-B

Figure & Index No.	Description	Manufacturer	Part No.	Qty	Reference Designation
7-12	ET-300M-B MODULATOR				
-1	PAD		BS102-61	3	
-2	FILTER ASSEMBLY		FU-301	1	
-3	CABLE		RG-55/U	A/R	
-4	RIGID CABLE ASSEMBLY		SP1450-22	1	
-5	CONNECTOR	AMPHENOL	36875	2	
-6	CONNECTOR		UG-492B/U	1	
-7	ADAPTER "N" JACK/OSM PLUG		21030	2	
-8	MICROSWITCH	HEWLETT/ PACKARD	33122A	1	
-9	RESISTOR, VARIABLE 1K	OHMITE	AS3604	1	
-10	CAPACITOR, 0.1 MFD	MALLORY	PVC101	1	
-11	RESISTOR, VARIABLE, 250K	OHMITE	AS3611	1	

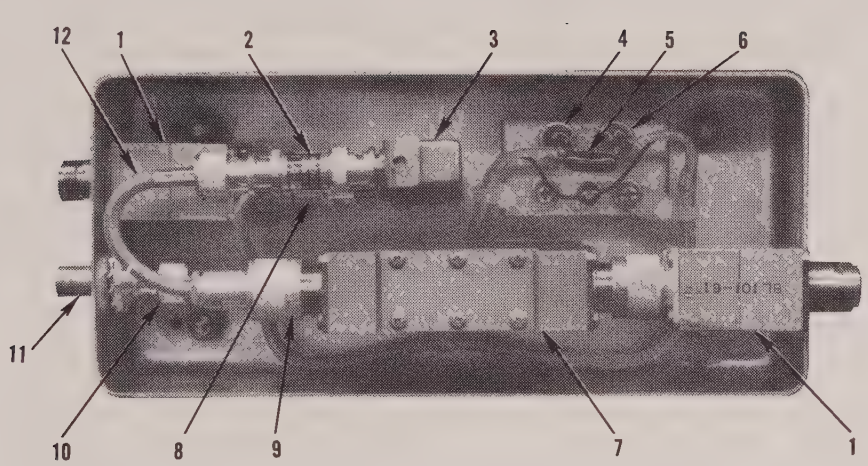


Figure 7-13. Time Delay Modulator ET-300M-A

Figure & Index No.	Description	Manufacturer	Part No.	Qty	Reference Designation
7-13	ET-300M-A MODULATOR				
-1	PAD		BL-101-61	2	
-2	3-DB ATTENUATOR	APPLIED RESEARCH INC	HFA (50)	1	
-3	MIXER	RELCOM	M1	1	
-4	RESISTOR, VARIABLE, 25K	OHMITE	AS3604		
-5	CAPACITOR, 0.1 MFD	MALLORY	PVC101	1	
-6	RESISTOR, VARIABLE, 1K	OHMITE	AS3608	1	
-7	FV-304 FILTER		05075000	1	
-8	CONNECTOR ADAPTER		UG-349A/U	2	
-9	CONNECTOR		UG-492B/U	1	
-10	CONNECTOR	AMPHENOL	36875	2	
-11	CONNECTOR, TYPE "N"		UG-536B/U	1	
-12	CABLE		RG-55/U	A/R	

APPENDIX

APPLICATION NOTES

RANTEC DIVISION
EMERSON ELECTRIC CO.
CALABASAS, CALIFORNIA

TM-107

1 August 1967
Rev 18 August 1970

APPLICATION NOTE:

CALCULATION OF PHASE PLOTS FROM TIME DELAY-VERSUS-FREQUENCY CURVES

Prepared by:

David G. Carson

Rantec Division of Emerson Electric Co.
Calabasas, California

CALCULATION OF PHASE PLOTS
FROM TIME DELAY-VERSUS-FREQUENCY CURVES

Time delay through a device is described as $t_d = d\phi/d\omega$ where ϕ and ω are expressed in radians and radians per second, respectively. Since time delay is the slope of the phase-versus-frequency curve, it is possible by integration to construct a phase-versus-frequency curve from time delay-versus-frequency data. Obviously, a flat (horizontal) time-delay curve indicates a linear (but sloped) phase curve. The slope of the phase curve represents the time delay of the flat portion of the time-delay curve.

Often the insertion time delay of a device being tested is so large with respect to the time-delay variations across the frequency band of interest that relative time-delay variation data is of more value. Obtaining this data permits scale expansion and magnification of the delay variations with increased accuracy. In such cases the derived phase data is of value in that it shows deviations from phase linearity. The linear slope used as a reference is a function of the particular integration process used (i. e., selecting a larger value of time delay as the integration reference decreases the slope of the linear phase reference).

In calculating the phase curve, the Δ frequency is generally in MHz and the time delay in nsec. The phase curve is calculated as follows:

$$t_d = \frac{d\phi}{d\omega} = \frac{d\left(2\pi \frac{\phi}{360}\right)}{d(2\pi f)} = \frac{d\phi}{df\,(360)}$$

ϕ = (degrees)

f = (Hz)

t_d = (seconds)

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$$\Delta\phi = t_d\,(360)\,(\Delta f)$$

$$\Delta\phi = t_d\,(10)^{-9}\,(360)\,(\Delta f)\,(10)^{6}$$

$$\Delta\phi = (0.36)\,t_d\,\Delta f$$

ϕ = (degrees)

f = (MHz)

t_d = (nsec)

An example of a manual integration technique is shown in Figures 1 and 2 for a single-section, time-delay equalizer at X-band. The 5-MHz, Δf increments were chosen as suitable with respect to the time-delay slope. Increased accuracy would result with smaller increments. Since the integration errors are cumulative, the area of prime interest is at the center frequency of the device being tested, and the linear phase slope is determined there, also; the integration was performed going both ways from center. The 4-nsec line was used as the time-delay integration reference, yielding a relative phase plot only. Integration using absolute time-delay data would have yielded an absolute phase data plot. The average time delay for each frequency interval was determined from the time-delay plot and the $\Delta\phi$ calculated from the previously derived formula. The calculated $\Delta\phi$'s occur over their respective frequency intervals. A total phase plot results from summing the $\Delta\phi$'s, then plotting each half of the curve separately. The slope of the calculated curve is lower than the measured curve, meaning that the deviation between the two curves is less than it appears. In addition, the cumulative error effect is obvious.

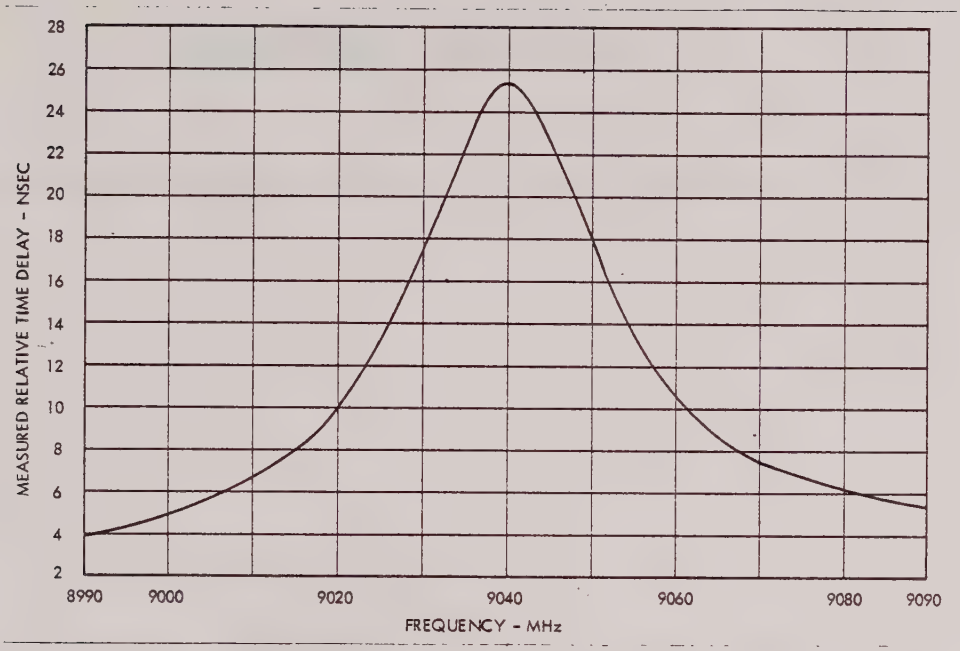

Figure 1. Measured Relative Time Delay Vs. Frequency for Single Section Equalizer

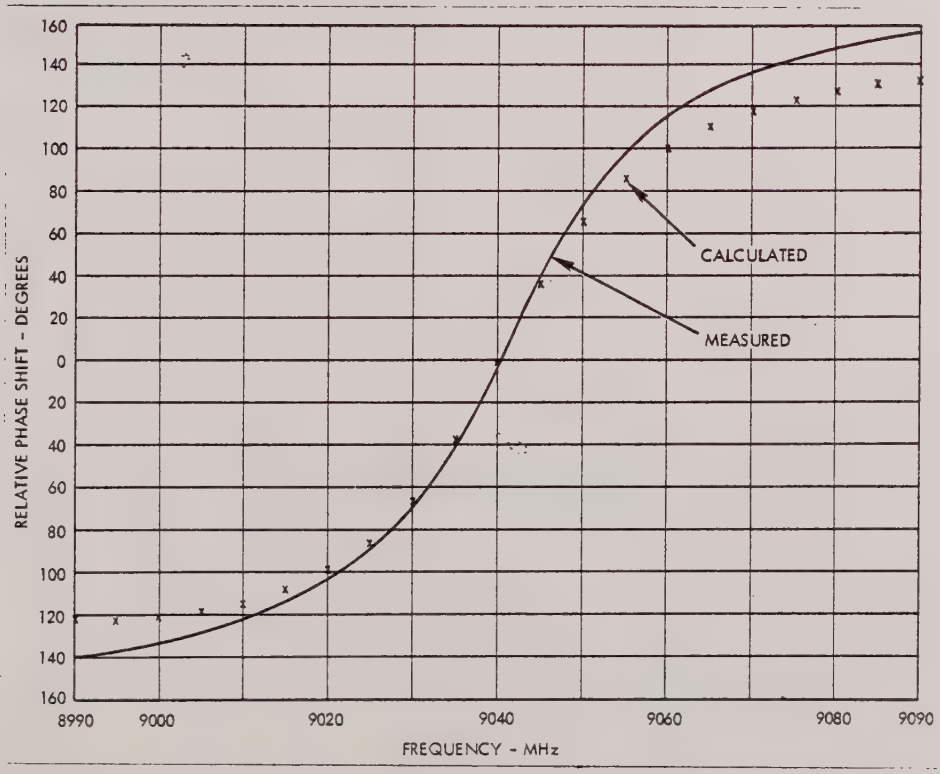

Figure 2. Phase Vs. Frequency for Single Section Equalizer

RANTEC MEMO

TM-108
January 1968

APPLICATION NOTE:

TIME DELAY MEASUREMENT OF FREQUENCY TRANSLATION AND ACTIVE DEVICES

Prepared by:

David G. Carson

Rantec Division of Emerson Electric Co.
Calabasas, California

rantec®

TIME DELAY MEASUREMENT OF FREQUENCY TRANSLATION AND ACTIVE DEVICES

When the input and output frequencies of a device differ or the device introduces gain in the system, several precautions must be taken in measuring its time delay-versus-frequency characteristics with the Rantec ET-300 Time Delay Instrument. Special consideration must be given to signal levels and to obtaining time delay references (with and without compatible connectors on modulator and detector units).

Power Level Considerations

Devices to be tested (with or without frequency translation) often contain active elements with appreciable gain and occasionally some loss. The reference time delay condition (power level and time delay) is obtained by connecting the ET-300M( ) Modulator and ET-300D( ) Detector Units and increasing the R-F generator power to the maximum permitted level (top of green band of level meter on ET-300E Electronic Unit) across the frequency band of interest. Use of an R-F leveler on the generator output will provide more useful test device attenuation range by operating closer to the maximum level over the selected R-F band. Do not increase R-F input power to modulator above this level because the modulator will become saturated, yielding erroneous results.

The ET-300 system will now measure time delay characteristics of a test device to specified performance over an attenuation range of 0-10 db. A useful range exists (not to specification limits) from 10 to 20 db. Square-law operation of the Detector generates a 20-db Electronic Unit signal from the 10-db test device attenuation range.

The gain of an active test device must be padded down to set the operating signal at a level near the maximum permitted as indicated by

the ET-300E level meter. To assure that no time delay errors are introduced by the pads, they may be comprised of small values (e.g., 6-10 db) for which the time delay characteristics have been measured. Only negligible error is introduced due to padding. Lowest VSWR pads (1.25 max) will generate minimum VSWR interaction problems.

The test device should be operated in a linear region to prevent time delay measurement errors that result from detected modulation zero-crossing shift with asymmetrical amplitude distortion. In addition, care should be exercised if the R-F input power to the Modulator is reduced to restore the desired Indicator signal level, because time delay error will be generated by the attenuation of the test device. This error is the result of a lower ratio of test signal level to modulation leakage.

Time Delay Reference

A time delay reference is required to determine absolute time delay of a test device or to subtract out a residual for very accurate measurements. This reference is normally obtained by directly connecting the Modulator and the Detector, rotating the resolver on the Electronic Unit for a nominal zero indication across the band of interest, and recording or observing the time delay characteristics. Then, insertion of the test unit between the R-F modules permits direct reading of absolute time delay with scale expansion for increased resolution by subtracting a known amount of time delay with the ET-300E resolver.

For frequency translation devices, the input and output frequencies of the device under test are different. If the two frequencies fall within the coax range of the ET-300 system (20 MHz to 8 GHz), the time delay reference is obtained in the manner previously described. The reference should be obtained using the input frequency to the test device. Time delay variation in the residual versus frequency is essentially due

to the modulator. Insertion of the test unit and detection of the envelope at a different output frequency by the Detector will introduce negligible error.

For non-compatible Modulator-Detector units (e.g., 12-GHz input to 6-GHz output) an accurate reference is difficult to obtain. A coax-to-waveguide adapter is required, and it generally must be removed when the test unit is inserted. In addition, although the detector in the coax unit is satisfactory to 12.4 GHz, the pad VSWR degrades. When up-converting from the coax to waveguide bands (i.e., 6 GHz to 12 GHz) the waveguide unit's detector is not capable of 6-GHz measurement and, hence, a reference cannot be obtained.

With no reference, only relative time delay measurements are possible, i.e., time delay across the band of interest through the device under test.

TM-123

1 June 1970

APPLICATION NOTE

SIMULTANEOUS AMPLITUDE AND TIME DELAY MEASUREMENTS

Prepared by:

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Rantec Division
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EMERSON ELECTRIC CO.
CALABASAS, CALIFORNIA

The Rantec ET-300 series of Time Delay Measurement Instruments are designed to accurately measure and conveniently display envelope or group delay (phase linearity) on transmission of an R-F signal through a device under test. Other application notes describe measurements for active and frequency translation devices, and calculation of phase characteristics from time delay data. Accurate measurements can be made with test unit insertion loss variation of up to 10 db; this is normally adequate since time delay measurements are conventionally made over the passband of a device where the insertion loss (and variation) are low. An auxilliary amplitude output is provided to permit simultaneous amplitude and time delay displays (i.e., on a dual display scope). This non-calibrated expanded (3 db/half scale) amplitude output has a useful range corresponding to the time delay amplitude variation capability, and is useful for maintaining a relative passband characteristic while equalize tuning a test unit (i.e., filter).

In certain applications it is desirable to display, simultaneously with time delay information, a larger amplitude dynamic range. This permits observation of filter skirt characteristic versus time delay equalization tuning across the passband. Several techniques are available which require additional equipment. In all cases, the R-F generator used must be leveled.

The Rantec ET-110/210 Series Phase (Amplitude) Impedance Measurement Instrument can be used to accurately extend the amplitude measurement range to 65 db. (See Product Data Sheet for characteristics.) The systems should be connected as shown in Figure 1. Both systems are compatible with respect to sweep speeds (i.e., 10-30 sweeps/second, depending on rate of change of data). The following is an equipment test for two typical levels of of interest:

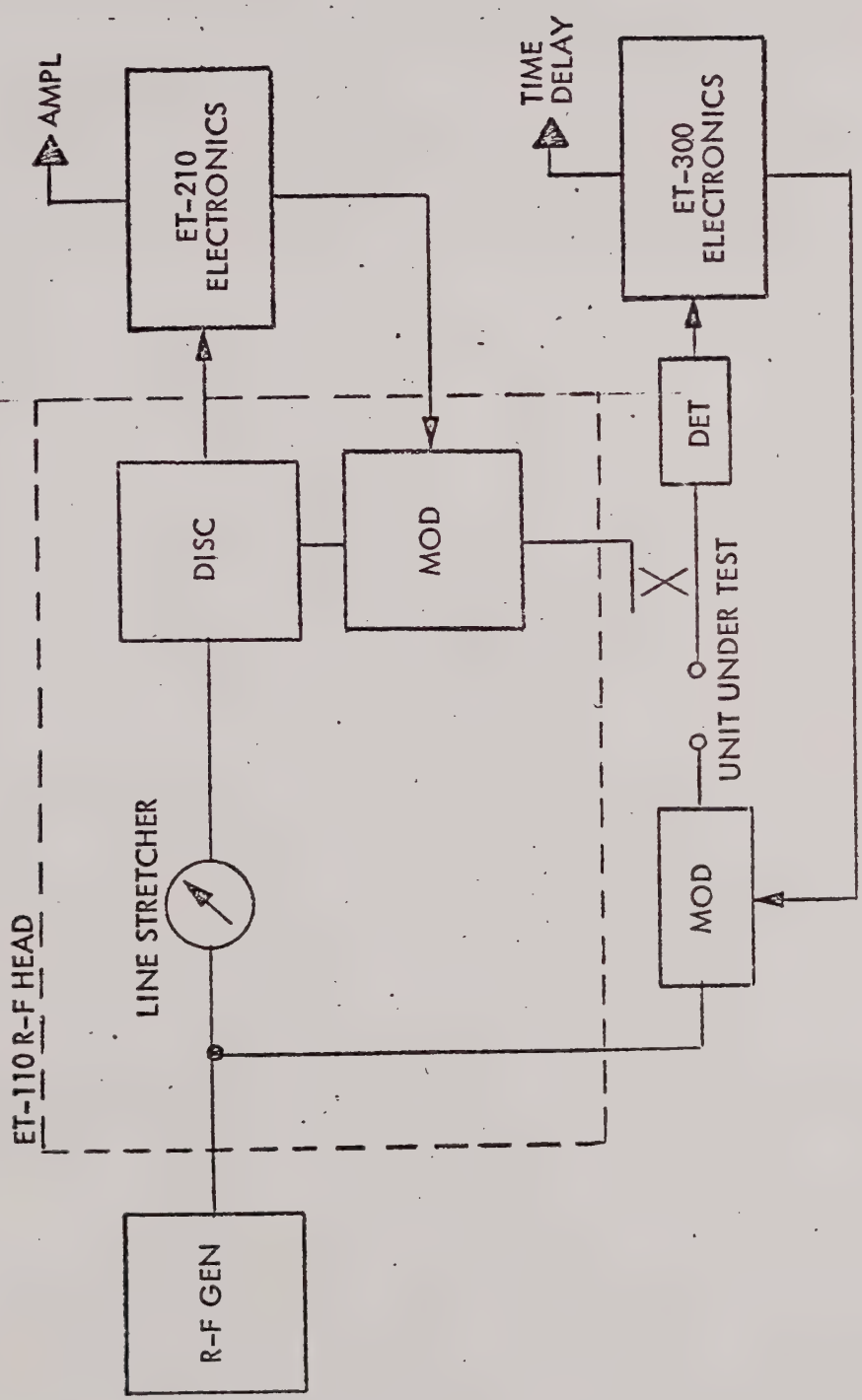

Figure 1. Block Diagram, Simultaneous Time Delay Wide Range Amplitude Measurement System

	70 MHz	4-6 GHz
Time Delay Indicator	ET-300E	ET-300E
Time Delay Detector	ET-300DAB	ET-300DAB
Time Delay Modulator	ET-300MA	ET-300MB
Multifunction Indicator	ET-210E	ET-210E
R-F Head	ET-110V	ET-110CX

The 210 R-F heads may be substituted if full R-F measurement coverage is desired.

If it is desirable to display the entire 65 db amplitude characteristic in one range (eliminate 20 db range switching of ET-210E amplitude circuits), a logarithmic converter can be used on the ET-210E 2-KHz output test point. The HP7562A is satisfactory except for slewing speed on swept displays. The Rantec logarithmic converter, LA-1, has similar performance, but its speed is compatible with the rest of the system.

If amplitude only, with logarithmic video output characteristic, is desired, the ET-110 R-F heads can be simplified, and the amplitude and logarithmic circuits packaged separately at a cost saving.

For reduced amplitude range and sweep speed, the generator can be 1.0 KHz modulated and a ratio meter used to indicate insertion loss with couplers and bolometer detectors before the ET-300 modulator and after the unit under test. Similar operation can be used with a coupler after the unit under test and insertion loss indicated on a VSWR meter.

ET-300 Precision Time Delay Measurements From 20MHz to 18GHz

RANTEC's ET-300 Series of Time Delay Measurement Instruments accurately measure R-F and microwave time delay (group delay) through active and passive devices. These instruments are insensitive to attenuation variations and signal source characteristics, and they provide swept measurements of time delay and amplitude response versus frequency or other control parameter on an oscilloscope or recorder. A common solid-state electronic unit mates with interchangeable broadband R-F modulator and detector units. Four wide-band modulators and three wide-band detectors cover 20 MHz to 18 GHz. Modulator and detector interchangeability permits testing of frequency translation devices.

FEATURES AND BENEFITS

- High resolution—within 0.1 nsec.
  Enables extremely accurate time delay measurements.
- Interchangeable R-F modules for 20 MHz to 18 GHz coverage.
  Meets modern broadband system requirements.
- R-F input and output signals can be in different frequency bands.
  Permits use in frequency translation systems.
- Ten linear delay scales from ±5 to ±2500 nsec.
  Provides for measurements over wide ranges.
- Precision continuous offset control.
  Allows offset of insertion delay and scale expansion for increased accuracy.
- Selectable frequency resolution.
  Optimizes performance with respect to band width of device under test.
- Delay readout on meter, swept oscilloscope display, and x-y recorder.
  Provides scope and recorder output for testing, tuning, and hard copy.
- Amplitude output for oscilloscope and recorder.
  Permits simultaneous time delay and amplitude tuning.

TYPICAL APPLICATIONS

- Long-line communication systems
- Diversity link equalization at carrier or baseband
- Digital communications systems
- Satellite communications systems
- Common carriers
- Cable television—distribution and components
- Complete transmitter-receiver systems
- Mixers, receivers, and transponders
- Amplifiers and amplifier chains
- Passive components for communications and radar subsystems

RANTEC ET-300E Time Delay Indicator

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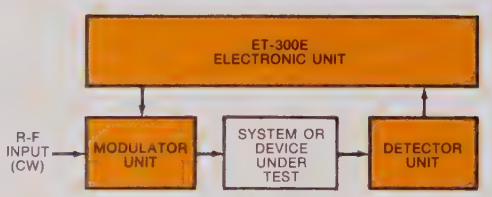
ET-300 Time Delay Measurement Instruments

TECHNICAL DATA



Block diagram of Rantec ET-300
Time Delay Measurement Instrument

R-F MODULES FOR USE WITH ET-300E TIME DELAY INDICATOR

R-F MODULATOR UNITS

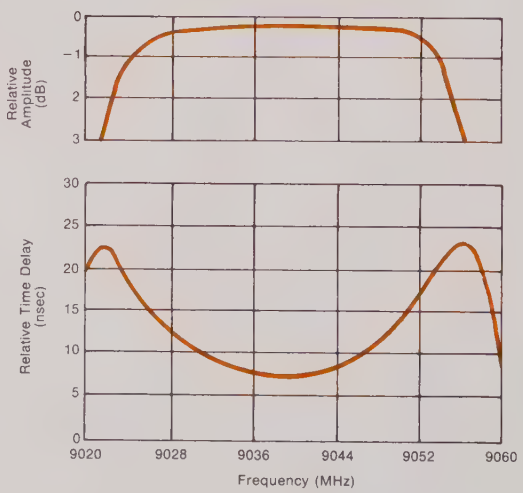
MODEL	FREQUENCY RANGE	TEST TERMINAL	INPUT TERMINAL
ET-300M-A	20-500 MHz	Coaxial N Female*	Coaxial N Female
ET-300M-B	0.5-8.0 GHz	Coaxial N Female*	Coaxial N Female
ET-300M-X	8.0-12.4 GHz	Waveguide WR-90	Coaxial N Female
ET-300M-Ku	12.4-18.0 GHz	Waveguide WR-62	Waveguide WR-62

R-F DETECTOR UNITS

MODEL	FREQUENCY RANGE	TEST TERMINAL
ET-300D-AB	20 MHz-8.0 GHz	Coaxial N Male*
ET-300D-X	8.0-12.4 GHz	Waveguide WR-90
ET-300D-Ku	12.4-18.0 GHz	Waveguide WR-62

*Other connectors, including GR-874, GR-900, and Amphenol APC-7, can be furnished on special order.

TYPICAL ET-300 OUTPUTS



Amplitude and time delay response for a correctly tuned communication channel or filter.

SPECIFICATIONS

R-F POWER
10 mw CW into modulator unit provides full dynamic range. Modulated R-F output approximately 0.1 mw (−10 dbm)

MODULATED FREQUENCIES 1.0 MHz or 0.2 MHz

DELAY READOUT (NSEC)

	Modulation Frequency 1.0 MHz	0.2 MHz
Unambiguous range	1000 nsec	5000 nsec
Linear scales on meter and displays	±5, ±15, ±50 ±150, ±500 nsec	±25, ±75, ±250 ±750, ±2500 nsec

AMPLITUDE READOUT
DC output for oscilloscope and recorder — square-law response of output signal from unit under test

DELAY VARIATION VERSUS R-F ATTENTUATION
(a) At 1.0 MHz modulation ± 0.5 nsec maximum in 0-10 db range
(b) At 0.2 MHz modulation ± 2.5 nsec maximum in 0-10 db range

DELAY RESIDUAL VARIATION VERSUS FREQUENCY (correctable by subtraction)
(a) Coaxial R-F modules ±3 nsec per octave, ±1 nsec per 10% band, typical (except for 12 nsec slope in 20-30 MHz band)
(b) Waveguide R-F modules ±2 nsec in full band, ±1 nsec per 10% band, typical

ACCURACY OF ABSOLUTE DELAY AND RELATIVE DELAY MEASUREMENTS
(a) At fixed R-F frequencies
1.0 MHz modulation ±0.1 nsec ±2% of reading but not exceeding ±5 nsec
0.2 MHz modulation ±0.5 nsec ±2% of reading but not exceeding ±25 nsec
(b) At swept R-F frequencies, with correction for residual deviation (typical errors are given — affected by VSWR, bandwidth, complexity and round trip attentuation of unit under test)
1.0 MHz modulation ±0.3 nsec ±2% but not exceeding ±6 nsec
0.2 MHz modulation ±1 nsec ±2% but not exceeding ±26 nsec

NOTE:
Accuracies apply to the expanded delay scales used in conjunction with the delay offset dial.
On the −500 to +500 and −2500 to +2500 nsec scales, an additional ±1% reading error is permitted.

ENCLOSURE
Indicator unit supplied in enclosure 19½" wide by 7½" high by 17½" deep.
Sides easily removed for rack mounting. R-F modules are furnished in separate compact housings.

Application notes and various standard options for special requirements are available; consult manufacturer.

EMERSON RANTEC DIVISION 24003 Ventura Blvd., Calabasas, CA 91302 • Telephone (213) 347-5446 • TWX 910-494-1218

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Rantec Doc. No. TM-139 25 February 1975

APPLICATION NOTE

DIVERSITY LINK – TIME DELAY MATCHING

Prepared by

G. J. McVicker
Senior Member, Technical Staff

RANTEC DIVISION
EMERSON ELECTRIC CO.
CALABASAS, CALIFORNIA

1.0 GENERAL

When switching links in a diversity communication system under fading conditions, digital data errors will be introduced if the two links are not time delay matched. Diversity link time delay matching can be achieved with the Rantec ET-300E Time Delay Measurement System. Matching can be performed on a baseband or individual channel basis.

This performance is achieved by using the fundamental modulating frequencies in the ET-300E Electronic Unit.

2.0 BASEBAND EQUALIZATION

Figure 1 depicts a typical setup for accomplishing baseband equalization. The ET-300E Electronic Unit MODULATION output is connected directly to a transmitter which goes, via any link arrangement, to the distant transmitter site to be equalized. A MODULATION FREQ switch is provided on the ET-300E front panel for selecting either a 1-MHz or 200-KHz baseband.

The selected baseband signal is then transmitted back to the local site over one of the diversity links to be equalized. The baseband output of this link is connected to the ET-300E INPUT. A reference is then set on the ±5 nanosecond scale using the ET-300E TIME DELAY RANGE NANOSECONDS control. The outputs of the other diversity links are connected to the ET-300E INPUT and their equalization circuits adjusted to a time delay equal to that of the first link.

Using this procedure, links can be matched within a few tenths of a nanosecond.

Note that the ET-300E INPUT terminal has a bias voltage of either +15 or -15 volts dc (rear panel switch selected) from a 1000-ohm source impedance. This voltage should be blocked with an appropriate capacitor if it will affect the equipment being tested.

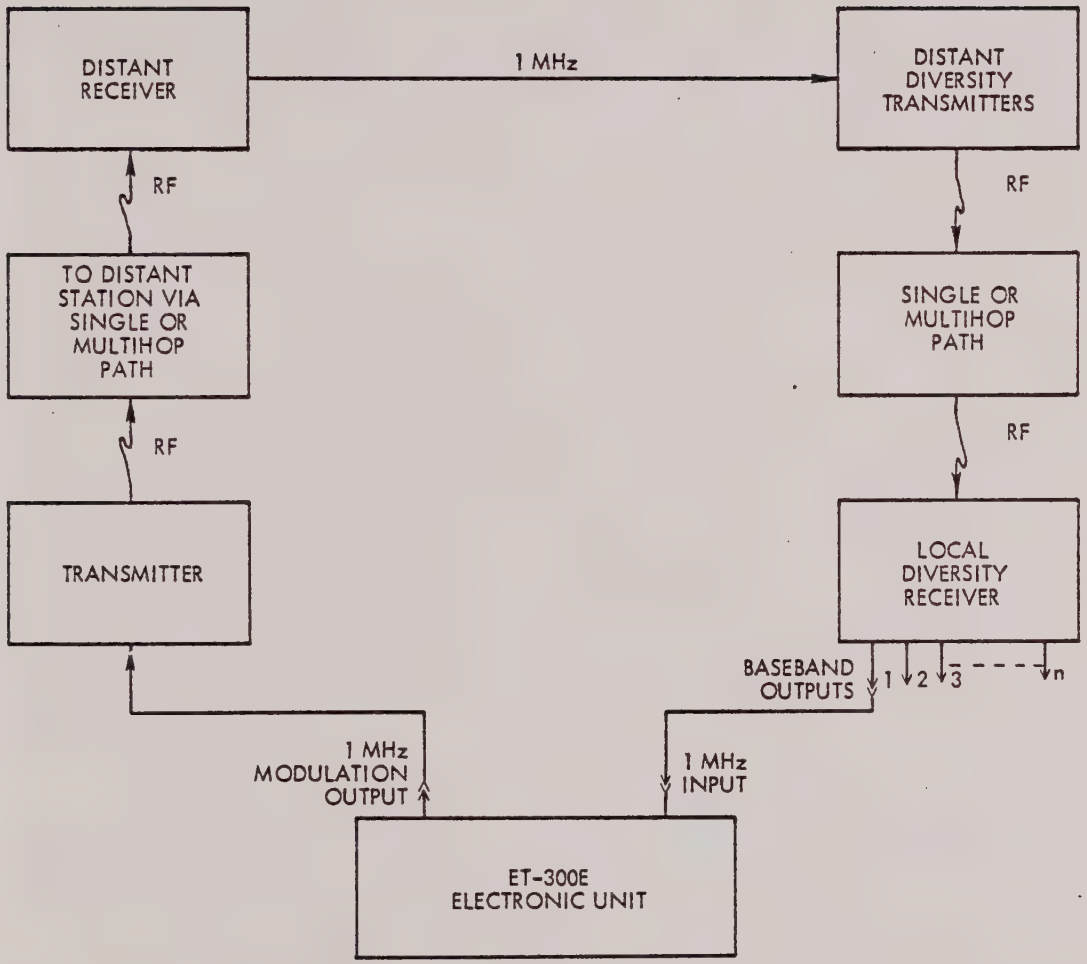

Figure 1. Baseband Diversity Equalization

3.0 INDIVIDUAL CHANNEL EQUALIZATION

Figure 2 depicts a typical setup for accomplishing individual channel equalization. An ET-300E Electronic Unit with Option 202 is required to perform the measurements. Option 202 brings the internal 2-KHz phase reference signal out through the MODULATION output connector, and a third position is added to the MODULATION FREQ switch. When operating at 2 KHz, the "red" nanosecond delay readings are to be multiplied by 100.

The 2-KHz modulation output is connected to one transmit multiplex channel and transmitted to the distant transmitter site to be equalized. Transmission to the distant site may be by any link arrangement. At the distant site, the 2-KHz signal is transmitted back to the local site using the multiplex channel to be checked, and the output of the local demultiplex channel is connected to the ET-300E INPUT. A reference is then set on the most expanded meter scale using the ET-300E TIME DELAY RANGE NANOSECONDS control. The outputs of the other diversity links are connected to the ET-300E INPUT and their equalization circuits adjusted to a time delay equal to that of the first link.

This procedure can be repeated on all multiplex channels throughout the entire baseband to provide a completely matched communication system.

Note that the ET-300E INPUT terminal has a bias voltage of either +15 or -15 volts dc (rear panel switch selected) from a 1000-ohm source impedance. This voltage should be blocked with an appropriate capacitor if it will affect the equipment being tested.

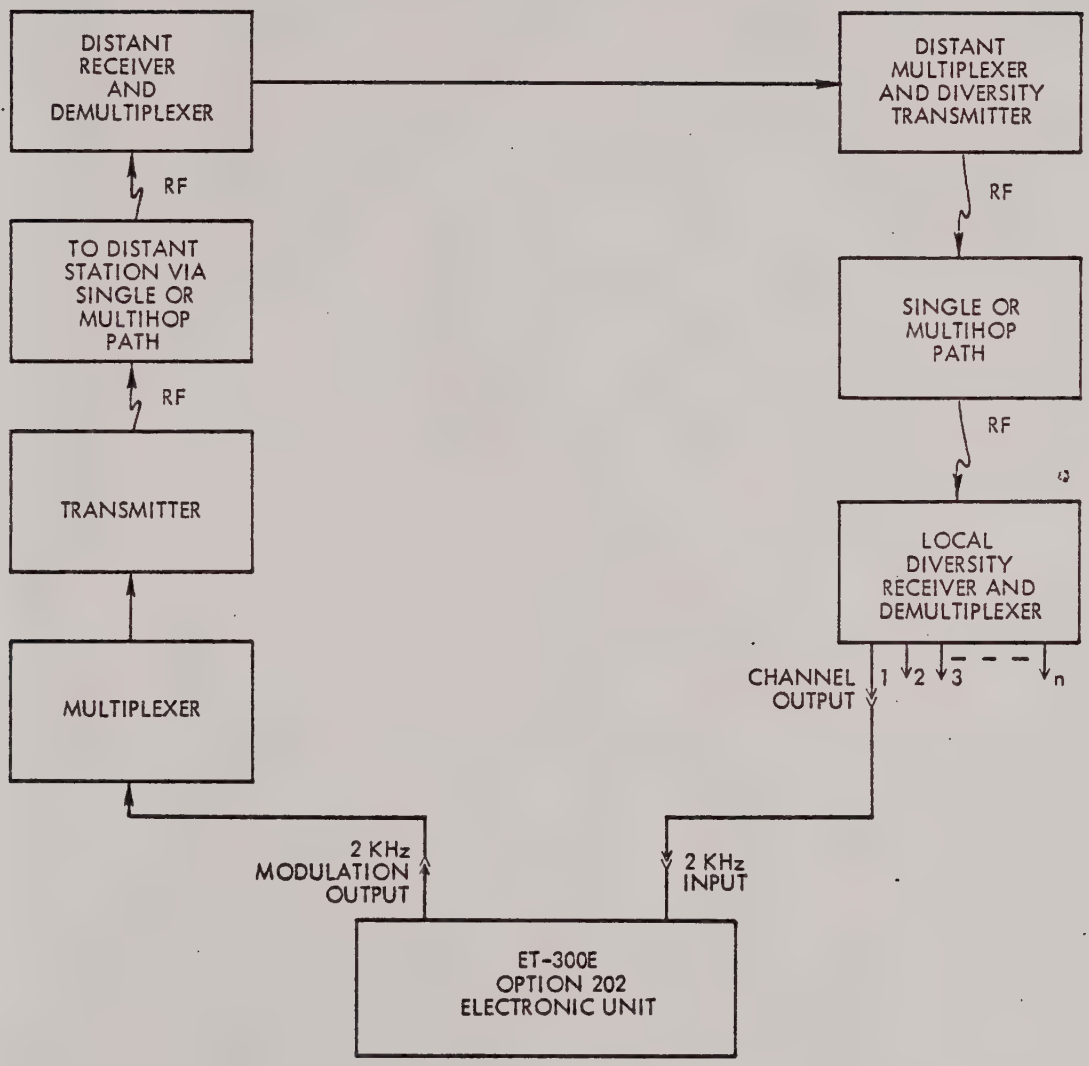

Figure 2. Individual Channel Diversity Equalization

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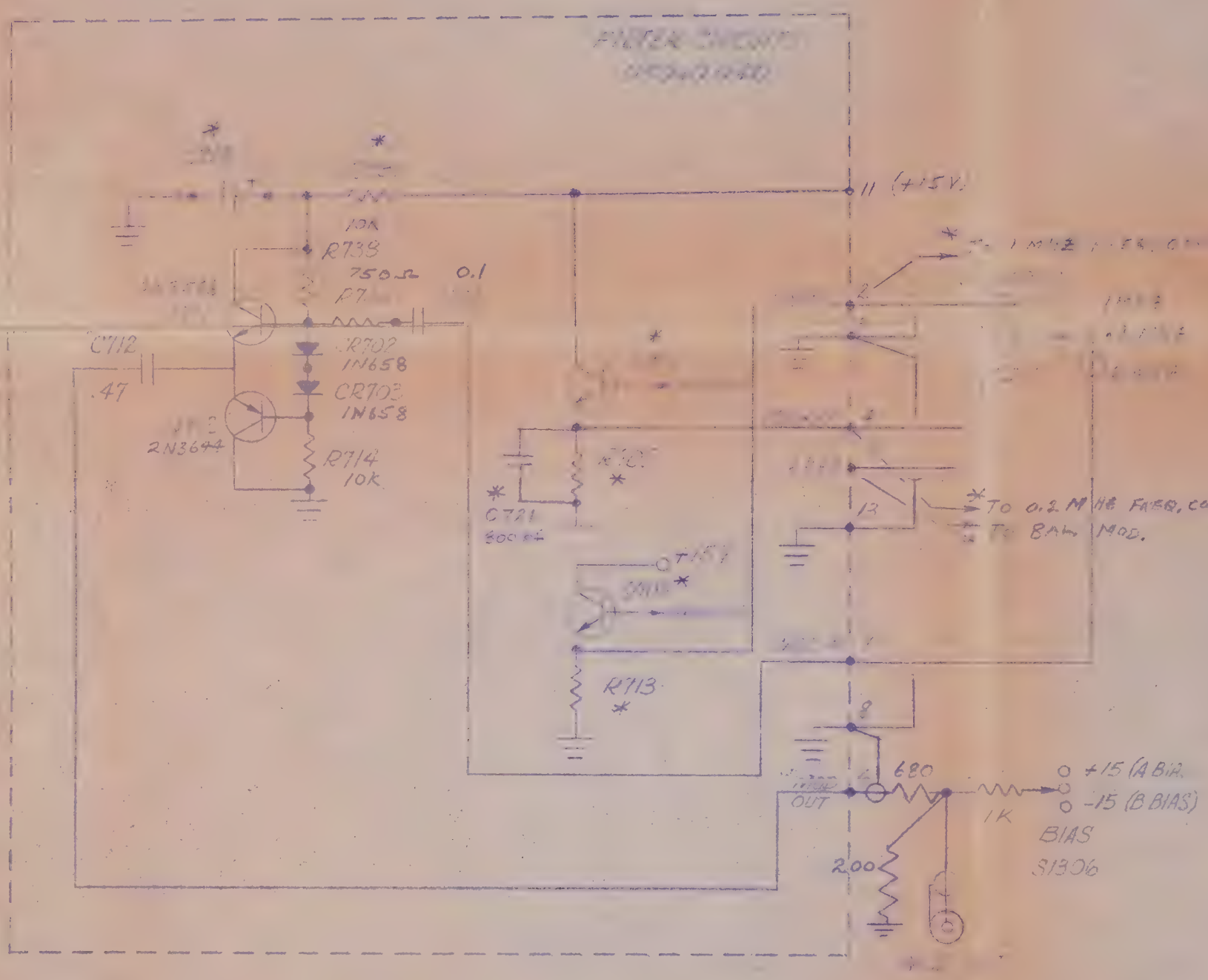


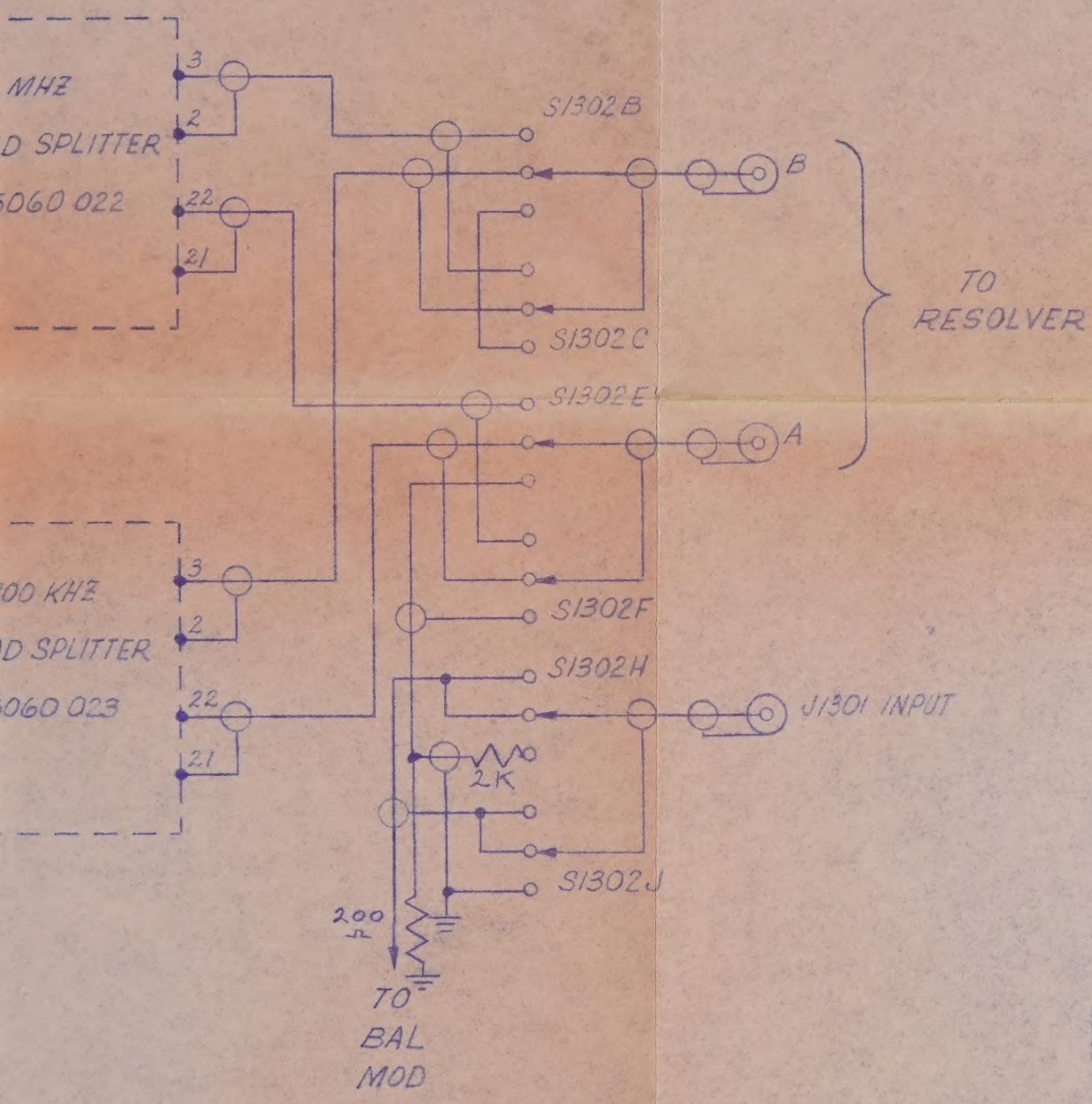
NOTE: * EXISTING

CHANGE R100 ON BAL MOD (100Ω) TO 300Ω

DELETE EXISTING R738 (100Ω)

REPLACE R728 (220Ω) WITH JUMPER

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



ITEM NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION OR CODE IDENT	QTY REQD
		LIST OF MATERIALS			

UNLESS OTHERWISE SPECIFIED INTERPRET PER MIL-STD-100
DIMENSIONS ARE IN INCHES
TOLERANCES ON
2 PLACE DECIMALS ±.03
3 PLACE DECIMALS ±.010
ANGULAR ±0°30'
BREAK SHARP EDGES .010 MAX
MACHINED FILLETS .010R MAX

MATERIAL:

CONTRACT NO.

DRAWN	P. M. Eugenio	DATE 6-6-75
CHECK		
ENG	D Carlson	7/25
APPR		

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ET-300 OPTION 202 CHASSIS WIRING

SIZE	CODE IDENT NO.		REV
C	04971	05060 042	

SCALE —

SHEET 1 OF 1

05060 042

MP MASTER
MA23843

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